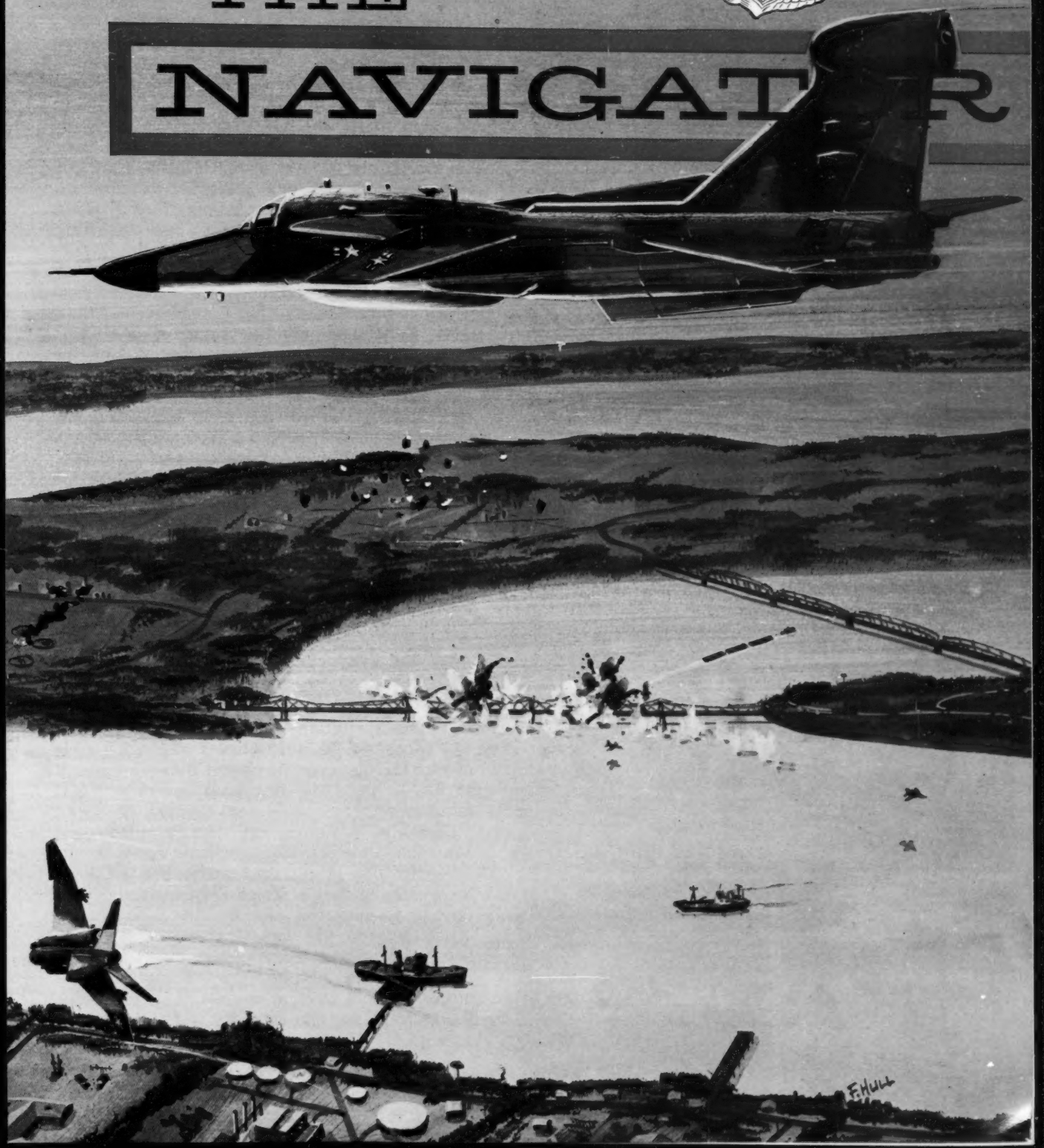
AFRP 50-3, Volume XXVI, Number 3, Winter 1979

THE NAVIGATOR



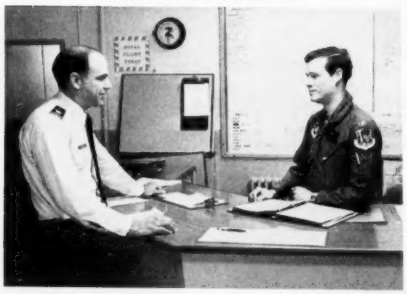
NAV OF NOTE

Lieutenant Colonel William E. Collins, an F-111 weapons system officer (WSO), assumed command of the 495th Tactical Fighter Squadron at RAF Lakenheath, England, on 12 June 1979.

Until a few years ago only pilots could command flying organizations, according to Title 10 of the US Code.

At the time of the Title 10 change by Congress, Colonel Collins was a weapons system officer at Mountain Home AFB. It was then that he set his sights high—his first objective was to be a squadron commander. At the time, his goals seemed unattainable, but he didn't give up—and it paid off!

"My next goal is to become a wing commander," Colonel Collins stated with determination. "When you stop setting goals for yourself, you stop working. Sure, there were trying and difficult times; working with shortages of personnel and equipment, but we always managed to get the job done," he added. "Whether flying or cooking in the dining hall, we're all in support of the same mission—to insure we maintain the best airpower anywhere in the world." This type of attitude toward the mission and people, along with the knowledge and leadership, makes a good commander.



Besides being one of the first two navigators chosen to command a USAFE fighter squadron, he was a member of the first squadron to participate in the largest peacetime movement of aircraft in US history. Better known as "Creek Swing," this 1977 project entailed moving the entire fighter force of F-111Fs from Mountain Home AFB, Idaho, to RAF Lakenheath, England, while Lakenheath's F-4D Phantoms journeyed back to stateside.

Shortly after this successful operation, Colonel Collins was selected to be the assistant operations officer. From there, the doors continued to open wider, giving him the opportunity to, in his words, "...guide those who are experiencing the same problems I had in the past." This experience came from 1,500 flying hours of which more than 1,200 hours were spent in the F-111F.

Colonel Collins was commissioned through ROTC in 1965 at Rensselaer Polytechnic Institute in Troy, New York. From there, he attended the aircraft maintenance officer course at Chanute AFB, Illinois.

Following graduation, he was assigned as Field Training Detachment (FTD) Commander at Craig AFB, Alabama, where he completed conversion training for maintenance personnel making the change from T-33s to T-38s. This project lasted just over a year and in June 1967, he took on a similar task at Seymour Johnson AFB, North Carolina, converting the 4 TFW from F-105s to the F-4Ds. In addition, the FTD, in cooperation with the 4 TFW, provided the Imperial Iranian Air Force with the initial F-4 specialized maintenance training.

In March 1969, Colonel Collins was stationed in Southeast Asia where he held a demanding job as materiel officer for the 416th and 389th Tactical Fighter Squadrons.

On his return to the United States in April 1970, it was time for Undergraduate Navigator Training at Mather AFB, California, until December of that same year. Colonel Collins then decided to stay and complete the advanced Navigator Bombardier Training course.

"I wanted to fly the F-111," he commented, "that's why I took the course. I knew I was taking a big chance because only one person in each class went to F-111s while the rest went to B-52s. I was fortunate to score well enough to make it."

Departing California, he went to Idaho and Mountain Home AFB. After being a weapons system officer for three years, he returned to student status for a year at the Air Force Command and Staff College, Maxwell AFB, Alabama.

Returning to the "potato state" in 1975, he became a mission-ready aircrew member in the F-111F with the additional duty of wing executive officer. In April 1977, it was get ready for "Creek Swing" time...and you know the rest of the story.

FROM THE EDITOR

This issue should be of tremedous importance to all navigators. HQ AFMPC has generously provided an in-depth look at the navigator career field and how it is managed. We've all heard this subject addressed quite often in recent months; now we have it in writing, directed specifically to us.

We're sure that you'll have questions or will want to read more. Therefore, I ask that you write down your questions or comments and mail them to me today—NOT tomorrow. Go a step further, too, and develop some constructive suggestions that I can pass along. We must continue to move ahead—expanding our capabilities to accommodate new technology, new navigation systems, and new roles. Therein lies the challenge.

Thanks to the many top quality articles received, we have been able to widen the spectrum of subjects for this issue. You'll find stories involving the F-4, B-52, C-130, EF-111A, an Air Force Reserve navigator, and even a Soviet navigator! The history buff will want to read about flying in the corridors during the Berlin Airlift. Also included is a summary of the recent USAF Navigation Symposium held at the Air Force Academy.

With this type of fine support, the future issues of THE NAVIGATOR will be even better. Subjects concerning the role of the WSO and EWO—especially in ground attack or air-to-air missions—are most needed. Have any ideas?

Of particular interest, we regretfully announce the passing of Captain Philip Van Horn Weems, USN, Retired—a legendary pioneer in sea and air navigation. Captain Weems graduated from the US Naval Academy in 1912 and instructed not only NASA astronauts in spacecraft navigation, but also such pilots as Charles A. Lindbergh and Wiley Post on aircraft celestial navigation. An extensive article on Captain Weems appeared in the Summer '78 issue of THE NAVIGATOR.

TO THE EDITOR

Dear Editor

Regarding the letter by Capt Floyd in the Winter '78 issue, there appear to be three typographical errors in the rhumb line planning formulas (on page 31). In the distance formula, there appears to be an error in the denominator. "180" should be multiplied times the rest of the denominator, not the first term as printed; i.e., $180\left[\text{Ln tan}(45+\tfrac{1}{2}L_2)-\text{Ln tan}(45+\tfrac{1}{2}L_1)\right]$. In the distance formulas, the top formula should read: "if cos C=0." The bottom formula should read: "if cos C≠0." The basis for these corrections is the Hewlett-Packard HP-25 Applications Program Manual. I have used the formulas as they appear in the application manual and have obtained correct results. A final comment, since the tangent function is a recurring function between -90° and +90°, most calculators will output results only between -90° to +90°. Thus, if the course is in a westerly direction, it may be necessary to subtract 180° from the result.

Frank T. Haloostock, Lt Col, USAF
Chief Avionics Engineer
HQ ASD/AER-EA
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Department of the Air Force

THE NAVIGATOR

AFRP 50-3, Volume XXVI, Number 3, Winter 1979

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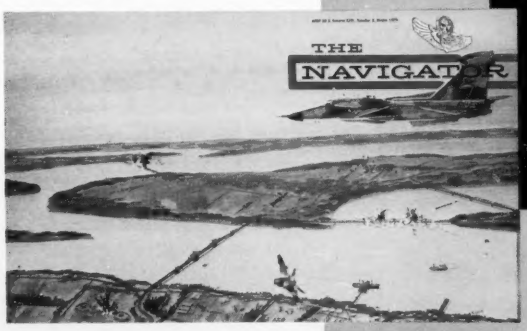


Our EF-111A on the near horizon provides a protective cover for the attacking Phantoms below. Further insight into recent developments affecting these aircraft can be found in "The EF-111A" on page 14, and "A Cosmic Computer for the Phantom" on page 10.

Where are we now and where are we going? AFMPC's "Navigator Management" on page 5 is a "must read" subject for all navigators.

Distribution: One copy per two navigators.

Navigator Management

Lieutenant Colonel James F. WILLETTE
AFMPC/MPCRT
Randolph AFB, TX

I wanted to write this article for several reasons. As a fellow navigator, I'm concerned with the many issues surrounding the navigator force as it exists today, plus I am curious about what the future holds for us. I have read several recent articles in such publications as the *Air Force Times, Aerospace Safety*, this magazine, etc., that concern not only the AF/MP-directed Navigator Utilization Study completed in February of this year, but other related subjects dealing with the drawdown of the rated supplement and the outlook for operational command opportunity for navigators. I'd like to draw all of that information together in this article and present it for your review. We'll focus on four major areas—how the navigator inventory and requirement structure affect us, projected increases in UNT production, the rated supplement prospects, and an update on navigator command opportunities.

NAVIGATOR UTILIZATION

The bases for future navigator utilization center about inventory and requirement forecasts for the next five to eight years. Regrettably, we hear all too often that there will be no place for navigators in tomorrow's Air Force. Phase I of the Navigator Utilization Study dealt specifically with this perception and revealed that over 9,000 navigator requirements would remain in all major weapon system groups (fighter, reconnaissance, bomber, tanker, strategic airlift, and tactical airlift) well into the 1980s. Jobs will be available in such aircraft as the F-4, F-111, RF-4, B-52, FB-111, various models of the -135, C-5, C-130, T-43, and even a small number in the C-141 in a troop airdrop role.

There is no doubt that certain navigator requirements are undergoing some changes, which means that some of us may have to change weapon systems, reorient ourselves to a different type of navigation, or even change from one basic Air Force mission to another. All of us are concerned about what we'll be doing in the future, so let's take a look at a couple of the major force structure changes that will affect our careers in the outyears.

We're all aware that line navigators are being drawn out of the C-141 due to dual INS installations. However, staff requirements demanding navigator expertise in that aircraft will remain into the 80s. Quite a few of the navigators with that background can look forward to filling those staff positions until about 1985. After that time, normal separations and retirements will have diminished the C-141 navigator inventory to the point that there will not be enough strategic airlift navigators left on active duty to fill all of the C-141 staff positions. While looking that far ahead is always risky, my guess is that the C-5 and some of the tactical airlift navigators will assume most of those responsibilities.

In the tactical fighter world, a portion of the F-4 squadrons are being converted to the newer, single-seat A-10s, F-15s, and F-16s. To preclude a large number of WSOs having to be reassigned to other major weapon systems, the Air Force will

reduce the number of new inputs, primarily from UNT, into fighters as the conversions take place. Thus, even though some F-4 squadrons are being phased out, WSOs currently on board should be able to stay in the fighter business for many years to come. Again, as with the C-141 navigators, multiple staff opportunities at wing, MAJCOM, and Air Staff levels remain for the WSOs.

There are three other factors that have affected, or may affect, the size of WSO requirements. First, in 1976, the Air Force retained four F-4 squadrons in USAFE beyond their original phase-out dates. These squadrons are still in the active inventory. Secondly, in 1978, two new F-4 squadrons were formed to meet tactical fighter force requirements in Korea and Alaska. With these initiatives, the F-4 will remain the largest single weapon system within the fighter force into the mid-1980s.

Lastly, the F-4G Wild Weasel and the expected EF-111 will continue a demand for WSOs with an electronic warfare officer background—probably into the 90s. There are also ongoing studies of follow-on two-seat fighters which may increase WSO requirements. However, that remains to be seen, and the fighter requirements detailed in the Navigator Utilization Study do not consider this possibility.

With a brief background on requirements, let's take a look at the current Air Force navigator inventory. We'll slice the inventory "pie" in a variety of ways to get an idea of who makes up our inventory and see what kinds of jobs we presently hold.

First, let's review the inventory by grade and navigator specialty. (NOTE: The charts are based on the lieutenant colonel and below navigator inventory since only that portion is matched against requirements.)

Navigator Inventory by Rank

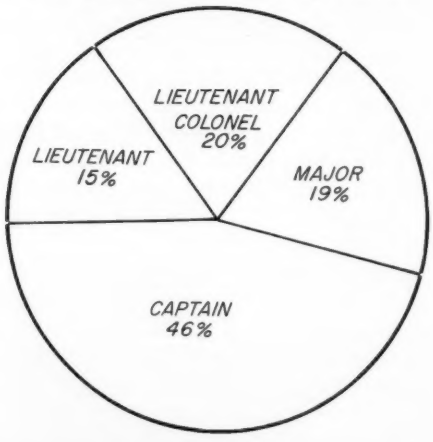


Figure 1

Figure 2 examines the "pie" in more detail, showing the navigator inventory by rank and weapon system background. Although some of us are not presently flying in the aircraft assigned to the various weapon system worlds because of current supplement and staff duties, our past operational experience would allow us to meet specific weapon system demands in times of national emergencies with little or no retraining.

Weapon System Inventory

Basic Nav

	Ftr	Recce	Tank	Strat Alft	Tac Alft	Msn Sup	Total
Lt Col	212	67	278	325	313	127	1,322
Maj	308	63	206	287	251	24	1,139
Capt	1,199	136	695	484	582	7	3,103
Lt	303	59	273	52	171	9	867
Total	2,022	325	1,452	1,148	1,317	167	6,431

Bomb Nav

	Ftr	Recce	Bomb	Other	Total
Lt Col	2	3	424	4	433
Maj	29	3	467	7	506
Capt	65	8	993	60	1,126
Lt	20	0	331	13	364
Total	116	14	2,215	84	2,429

EWO

	Ftr	Recce	Bomb	Tank	SAL	TAL	Msn Sup	Total
Lt Col	76	5	234	93	4	48	38	498
Maj	111	9	194	98	5	53	30	500
Capt	197	3	405	107	1	59	21	793
Lt	57	0	289	25	0	10	4	385
Total	441	17	1,122	323	10	170	93	2,176

Figure 2

Because the prior two figures don't really tell us what types of jobs navigators are currently holding, I've added a couple more charts. Figures 3 and 4 show jobs held by navigators by weapon system backgrounds and then by rank.

Jobs by Weapon System

	Ftr	Recce	Bomb	Tank	SAL	TAL	Msn Sup	Total
Crew	1,661	200	1,832	1,106	551	787	52	6,189
Staff	716	112	947	488	356	440	78	3,137
Suppl	174	37	513	214	224	265	128	1,555
AFIT	10	4	21	4	13	18	1	71
PME	18	3	24	9	15	13	2	84
Total	2,579	356	3,337	1,821	1,159	1,523	261	11,036

Figure 3

Jobs by Grade

	Lt Col	Maj	Capt	Lt
Crew	228	599	3,747	1,615
Staff	1,106	1,111	913	7
Suppl	887	372	292	4
AFIT	3	4	64	0
PME	29	49	6	0
Total	2,253	2,135	5,022	1,626

Figure 4

When comparing the projected total navigator inventory with the known requirements across the USAF Five Year Defense Plan (FYDP) we

expect to reach a shortfall of about 1,000 navigators. This deficit manning dictates careful management of the navigator force. It obviously means that all of the requirements cannot be met. Some positions will go vacant. In the end, the MAJCOMs will have to determine in what areas shortages must be absorbed—crew, staff, or supplement. I doubt that we'll see many vacancies in the crew force. The line units represent the immediate combat capability of the Air Force and sustain our readiness posture toward deterring or responding to future conflicts. Thus, I would expect most of the shortfall to be assimilated in the staff and supplement areas. However, one must be careful, for if line units represent immediate combat capabilities, staff and supplement requirements represent our ability to plan, program, and direct future contingencies. Thus, shortages in any area must be delicately balanced against shortages in the other areas to insure that our overall combat posture, now and in the future, is not unacceptably degraded.

UNT PRODUCTION

New navigators must be brought into the Air Force each year to sustain the inventory and counter losses due to retirements, separations, groundings, and promotions to colonel. Phase II of the Navigator Utilization Study indicated a definite need to increase UNT production based on the expected shortfall at the end of the FYDP. Our current and projected UNT/NBT/EWOT rates are:

Navigator Production Rates

	UNT	NBT	EWOT
FY80	600	124	171
FY81	650	146	174
FY82	700	180	180
FY83	750	204	186
FY84	800	215	197

Figure 5

Of course, sustainment of each weapon system group depends on how graduating navigators are distributed to the various weapon system groups. Figure 6 shows expected distribution.

UNT Weapon System Distribution

	FY80	FY81	FY82	FY83	FY84
Ftr	153	79	59	41	39
Recce	10	10	12	21	22
Bomb	226	263	327	363	376
Tank	155	223	204	214	238
SAL	0	0	0	0	0
TAL	56	75	98	111	125
Msn Sup	0	0	0	0	0
Total	600	650	700	750	800

Figure 6

Because the programmed UNT rates will not raise navigator force levels sufficiently to meet total requirements, further increases in UNT production are presently under review by the Air Staff and OSD. It's too early yet to publish the results of that review in this article—there is simply not enough information available.

Many of us are concerned about two topics—the rated supplement and flying unit command opportunity. Let's turn our attention to each one of these separately.

RATED SUPPLEMENT

Over the past five years, the Air Force has experienced rated overages in both pilot and navigator ranks. There were several reasons for this situation. Following the Southeast Asia conflict, many of our older model combat and mission support aircraft were either transferred to the Air Reserve Forces or phased out completely. In addition, crew ratios were cut in MAC and SAC—MAC crew ratios were cut in half with establishment of the Associate Reserves; SAC's crew ratios were cut by around one-fourth during the post-SEA drawdown. Along with these force structure changes came associated flying hour and logistics support reductions. In 1970, the Air Force had 6.3 million flying hours available for combat and training operations whereas in 1979, flying hours now stand at about 2.7 million.

Faced with rated overages during a period of cockpit/flying time reductions, the Air Force made a conscious decision to place excess rated officers into nonrated duties. This move offered substantial benefits to both the Air Force and the individuals themselves. First, the Air Force retained its combat-proven rated force in reserve to meet future contingencies. Secondly, supplement duty provided a wealth of rated experience and field grade managers for many key support areas. Finally, more opportunities for individual career broadening and executive development became available.

These benefits were not gained without some attendant impacts, however. Due to the overages, UPT and UNT rates were reduced to their lowest levels since before the Korean War. As a result, we have fewer rated officers in the younger year groups. With rising separation rates, it has now become necessary to return many of the officers placed in the supplement to rated duties to fill those priority requirements. For the more senior officers, this return to rated duties is often viewed

as a dramatic turnabout in their career progression, yet we're faced with little or no alternatives until pilot and navigator production rates are increased sufficiently to meet our rated requirements. This does not mean, however, that all senior navigators are being returned to rated duties. In fact, over the past year and a half, nearly 40 percent of the lieutenant colonels serving in support career areas were extended in supplement duties beyond their normal tour completion dates.

Such supplement extensions are normally a result of the Rated Officer Review Board (RORB) actions. The RORB is chaired by the Chief of the Officer Career Management Division, and includes as members the Chiefs of the Rated and Support Officer Assignment Branches, a representative from the Rated Supplement Management Section, plus an individual from the Force Utilization and Control Division. Basically, the RORB makes initial recommendations, on a case-by-case basis, concerning future utilization of rated officers as they become eligible or available for reassignment. In other words, the board recommends that the officer either be retained in or returned to rated duties, be considered for entry into the supplement, or extended in support duties.

Many factors are weighed in the RORB's recommendations. The primary factor, naturally, is what is the overall best course of action for the Air Force. Rated force requirements must be balanced against the needs of the support career fields and the career impacts on the officers themselves. For example, in light of the current critical engineering shortfall, it may be in the best interests of the Air Force to place a rated officer with a "double E" degree into a Systems Command SPO even at the expense of creating a vacancy somewhere in the rated world.

There are many other factors also considered by the RORB. Individual desires, past performance records in rated and/or support duties, retainability within the Air Force, major weapon system currency, and proximity to primary zone considerations for promotion to colonel all become major players in the RORB's decisions as the supplement drawdown accelerates.

In 1976, over 7,700 rated officers (5,453 pilots and 2,259 navigators) were serving in nonrated positions. By the end of 1978, that figure had been reduced to less than 6,000 (3,999 pilots and 1,841 navigators) and by the end of 1980 we expect to have a supplement of only about 1,650 pilots and 850 navigators. Smaller supplement inventories dictate a corresponding loss of flexibility as to where rated officers can be assigned. Although some rated officers will continue to serve in nearly all support career fields, the majority will be assigned to research and development areas, the logistics field, and at the precommissioning sources such as the Air Force Academy, ROTC, and OTS.

Many navigators would like extended tours in the rated supplement—it's an arena that has traditionally provided opportunity for good jobs, accompanying levels of responsibility and slightly higher promotion rates. In trying to best manage our dwindling rated resources, however, we're faced with some "real-life" constraints. First, the Aviation Career Incentive Act pays rated officers $61,160 over a 25-year period to be available for rated duties whenever needed. Under current rated inventory shortages, agencies such as the General Accounting Office (GAO) and the Defense Audit Service closely scrutinize continued support duty for rated officers.

The second is that all navigators below the grade of colonel count the same toward the total inventory; the lieutenant colonel navigator with a PhD in laser physics, who is serving as a Division Chief and has earned four straight "1s," counts the same as the second lieutenant. Even though the former may be the one "key" member in a vital research effort, OSD and Congress will not allow us to assess a second lieutenant to replace him until he has either been promoted to colonel or has left the service. Thus, to meet rated requirements, in a period of shortfall, it's necessary for some of our senior navigators to either remain in or be returned to rated duties.

The third constraint, in accordance with past Air Force decisions/policy, is that rated positions have taken precedence over supplement jobs. This has evolved over the years because OSD and Congress compare our total rated inventory to rated requirements to fund the UNT rate. To assist in this area, there is a current initiative being worked by the Air Staff that identifies a need for rated presence in most support career fields with emphasis on the previously mentioned fields of research and development, logistics/maintenance, the precommissioning sources, plus plans and programs. This program would allow us to underman certain rated positions in order to place rated officers in the key support areas.

To summarize the supplement issue, the rated supplement will be reduced in the future, but it

does not mean navigator opportunity will be driven to zero. It does mean, however, that entry into support career areas will become more competitive and that the "hard-core" areas mentioned above will receive emphasis. Adherence to controlled tour lengths (normally, three years) will be followed to allow maximum flow into and out of nonrated duties which, in turn, permits more opportunity for as many officers as possible. It also means that navigators can expect to spend more of their time in operational duties throughout their careers.

OPERATIONAL COMMAND OPPORTUNITY

With a smaller supplement for the future, most of us are naturally concerned with the last topic I want to discuss—operational command opportunity for the navigator force. As you know, Title 10 restrictions for navigators were repealed in December 1974. Since that time, Air Force policy has been to select the best qualified line rated officer for command of flying units without regard for aeronautical rating. Although, as anticipated, movement in this area has been relatively slow, I believe things have really begun to pick up, especially during the last year. Navigators are being integrated into the traditional "stepping stone" positions such as flight commander and operations officer en route to operational commander billets. Eight navigators now command operational flying squadrons, five others command navigator training squadrons, and two have been flying wing commanders in MAC and ATC. There are also 25 navigators serving as operations officers in the 197 operational and flying training squadrons with navigator crew members. In the tactical fighter units, nearly 70 WSOs are serving as flight commanders in TAC, USAFE, and PACAF. WSOs are also being asked to perform SOF and RSU duty, which traditionally had been reserved only for pilots.

More recently, the Air Force Chief of Staff emphasized to the major air commanders the importance of giving navigators responsible jobs in the operations areas, including assignment as flying unit commanders. General Allen stated, "Flying unit commanders are a key element in our future leadership structure, and I consider it essential that they be identified from among all who are eligible to ensure that only the best qualified are selected. Navigators who demonstrate leadership potential should be

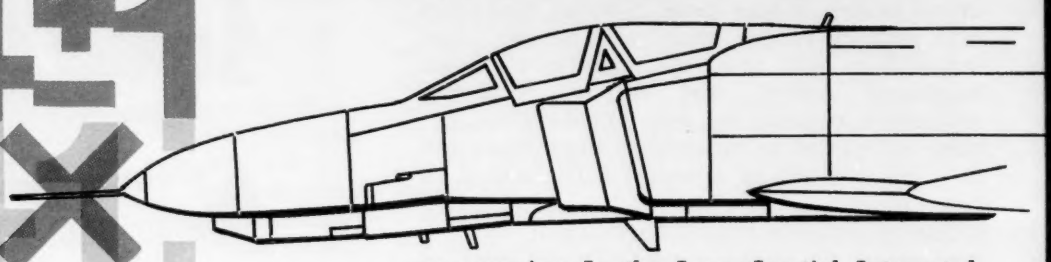
professionally developed and considered for operational command at all levels along with similarly qualified pilots."

When the highest level in the Air Force places that kind of emphasis on navigator command opportunity, I think you'll understand why I'm optimistic about the future. What we need now are navigators who are willing to remain in the operations area and compete for the command positions. I believe this will be the most important factor. Unless our best are willing to take the lead and compete in rated duties, I honestly don't think that navigator command opportunity in operations will ever rise much above what it is today.

In writing this article, I want to shoot "straight from the hip" and let you know about some of today's difficult issues facing the navigator force. Our force structure has undergone some pretty significant changes over the past few years—fewer aircraft, less flying time, reduced UNT rates—that have resulted in some tough challenges for the future. We aren't going to solve all the problems this year or the next, but you and I will be among those who will seek the solutions. Again, I think our outlook is bright—projections show a definite need for navigators in a variety of operational missions; although the supplement is being reduced, the opportunity will remain for the competitive officer; and finally, increased responsibilities in the operations arena are being realized.

Lt Col Willette entered the Air Force in 1960 as an aviation cadet and later completed electronic warfare officer training at Keesler AFB. He has served as a crew member in B-52, B-58, and F-4 aircraft, and had a previous tour at the Air Force Manpower and Personnel Center as Chief of the Navigator Assignments Section. Lt Col Willette is assigned to AFMPC and was Deputy Chief, Rated Officer Career Management Branch before his present duty as Chief, Training Management Division.

A COSMIC COMPUTER FOR THE PHANTOM 4+1 4X!



Editor's Note: The AN/ARN-101 system is an excellent example of "black box" navigation technology which includes the human element as the essential component, thereby greatly enhancing the probability of mission success.

Captain Raymond L. HENLEY
4444 OPS/FWS
Nellis AFB, NV

If you haven't spent the last three years TDY in the arctic, you probably have seen *Star Wars* and would undoubtedly agree that one of the most engaging characters in the movie was a computerized robot called R2D2. Among his other accomplishments, he made a pretty good GIB and assisted Luke Skywalker in destroying the bad guys' home drome. While the ingenious R2D2 was a marvel of fiction, using sophisticated, human-engineered computers in today's fighter aircraft is indeed a reality. All F-15, F-16, and F-18 aircraft are equipped with advanced computers. Now, a number of F-4Es and RF-4Cs are being modified to incorporate an advanced digital navigation and bombing computer. The computer is actually the heart of a larger modification called the AN/ARN-101 Digital Modular Avionics System. The ARN-101 replaces the Inertial Navigation Set, the Weapon Release Computer Set, and the old analog Navigation Computer Set. In addition, it adds a Loran receiver and provides interface for Pave Tack, the newest laser guided bombing system.

Built by the Lear Siegler Corporation, the ARN-101 is designed to enhance operation during all phases of flight. The navigation modes use information provided by a Loran receiver and a new inertial system. Under normal circumstances, the new inertial measurement unit and the Loran operate in a fully integrated mode using the best characteristics of each. Loran provides excellent long-term navigational accuracy, but is susceptible to error during abrupt maneuvering. Conversely, the inertial unit is less accurate than Loran over a long period of time, but is relatively unaffected by aircraft maneuvering. In the Loran-Inertial Integrated Mode of operation, these systems compare information and the Loran corrects inertial tendencies to "drift off." If the inertial position information is degraded, the Loran may be the sole source of navigational information or may be selectively supplemented by portions of the inertial system which are not malfunctioning. The GIB has the option of selecting Loran-inertial integrated, Loran with inertial velocity aiding, Loran with true airspeed velocity aiding, or Loran only. Additionally, pure inertial data only may be selected if Loran information is inaccurate and, of course, there is the old standby, DR mode. With DR selected, only TAS and heading information are available.

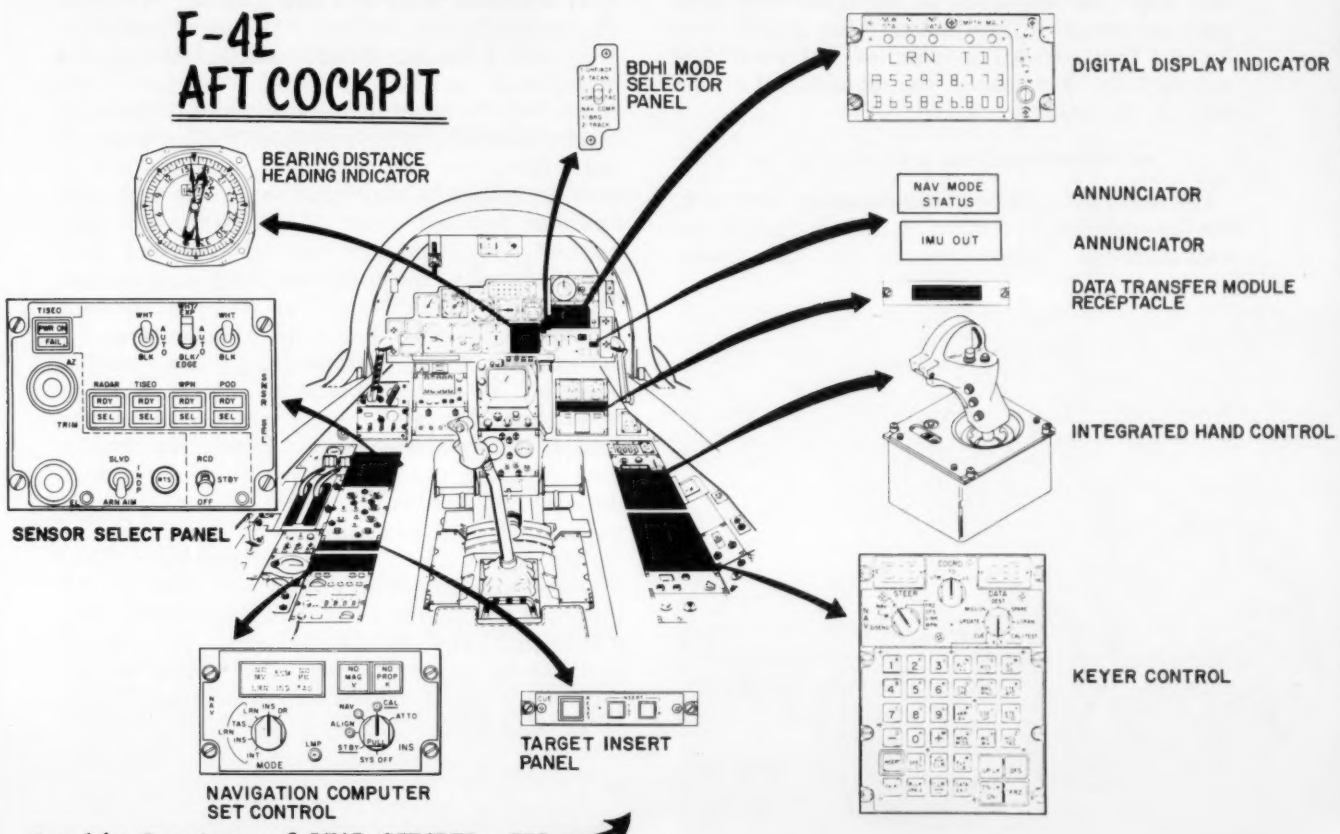
The GIB feeds navigational data into the computer using the keyboard and can insert data in latitude and longitude, UTM coordinates, or Loran TDs. The computer automatically converts any of the three into the other two. The system will accept up to 60 destinations which are entered as turn points, targets, and avoidance points. It then provides direct steering to either the selected point or to intercept a preselected course to the point. When coupled with the autopilot, the computer will provide these same functions. It flies the aircraft to each point in succession, automatically sequencing displayed navigation data. If you wish to avoid a particular area, insert the coordinates for that point and an avoidance radius. The computer will then fly the selected course, arc the avoidance point at the desired distance, and then reintercept course to the next turn point.

In the approach mode, the pilot receives steering and glide slope information on the HSI. Cross track error is also displayed on the digital display indicator in the rear cockpit, if desired. The aircraft commander can hand fly the approach or allow the computer to do the job in an autopilot-coupled mode. In this coupled mode, the GIB programs a go-around height. Unless the pilot takes control from the autopilot, the computer will attempt to level the aircraft when approaching the selected go-around height.

The weapons delivery functions of the ARN-101 are varied and complex. As I have mentioned earlier, this system was designed to interface with the Pave Tack system. It will also provide enhanced capability for advanced versions of the Maverick air-to-ground missile. That's not all; it has other Cosmic Electronic Mudbeating capabilities. In the blind bombing mode, it can deliver ordnance using only Loran information with an accuracy of 200 to 400 feet. The ARN-101-aided visual modes have an advertised accuracy of 7 mils and include a Constantly Computing Impact Point mode. Basically, this means that the pilot is not forced to fly strict parameters for a visual delivery. The pipper (aim sight) constantly displays where the bomb will impact if the pickle button is depressed at that moment. For the GIB it means some relief from the aural altimeter duties. Counting down to release altitude is no longer essential. While it's still a good idea to monitor the altimeter, so as to avoid exceeding the desired recovery altitude, the GIB has help in this area and can insert an alert altitude into the computer. When the computer "sees" an aircraft vector that will exceed the low altitude limit unless a 4G pull in 2 seconds is used, it warns the pilot by flashing the sight reticle and angle of attack indexer lights in both cockpits.

To sum up, the ARN-101 modification enhances the F-4E capability in navigation, bombing, and computer approaches. Unlike R2D2, however, our computer does not assume the entire GIB workload and does only what it is told. This means the GIB must be *proficient* in operating the computer. To keep you honest, the computer stores all data that you insert and on postflight will cheerfully display your mistakes to anyone who knows how to ask for the data! So for all you GIBs, be ready to hit the books hard when you get the ARN-101-modified aircraft. This system has a lot of potential, but is very demanding. Thorough system knowledge and extensive preflight planning will minimize heads-down time and maximize target destruction. Good luck and "May the Force be with you."

A graduate of East Texas State University, Capt Henley was commissioned through ROTC. In 1970, he completed F-4 training and was assigned to the 8 Tac Ftr Wg, Ubon, Thailand. Next came four years as an RTU instructor at Homestead AFB, followed by two years as Weapons Officer, 3 Tac Ftr Wg, Clark AB, Philippines. Currently assigned to the 4444 Ops Sq, Capt Henley also serves as an instructor in the F-4 Fighter Weapons School, Nellis AFB.



Graphic Courtesy of LEAR SIEGLER, INC.

WATCH OUT

Captain Thomas W. RUNYAN
11 AREFS
Altus AFB, OK

"Co, Nav, you've got a bad fix here!" Have you ever said that while scoring a celestial nav leg? "Whatayamean, Nav?" "Well, look here, I have an almost pinpoint three-star celestial fix, but your TACAN fix for the same time is eight miles southwest." A reasonable statement from any navigator refining his celestial techniques. "Look, Co, I'll DR out of your previous position using fix-to-fix info from your chart. Let's see, 12 minutes, 400 knots groundspeed, 80 nm, 325°—well, maybe this first fix was bad too?" "Nav, isn't it in the same spot as your radar fix on your chart?" Baffled again, the pinpoint cel fix was not reliable.

Has something similar ever happened to you? There it is, an apparently perfect three-star fix conclusively proven to be inaccurate. Perhaps you've plotted the copilot's fix on your chart and compared each LOP of your three-star fix with the TACAN fix. A strange pattern begins to develop after several missions. The further the shot is from fix time, the further the LOP falls from the actual position. Not always, but too frequently. And another peculiar observation—why does the magnitude of the error vary from perhaps twenty to zero miles? After awhile, you suspect that something is amiss. But what? Let me explain. Remember the equation for one minute motions?

$$MT = [GS/60 \{COS(Zn-TR)\}] + 15 \text{ COS LAT SIN Zn}$$

The first half, motion of the observer, is correct. But the second half, motion of the body, is only an instantaneous approximation in the total problem. The inaccuracy becomes obvious when a programmable calculator is used to solve a precomp. When you punch buttons for a celestial precomp, your calculator will triple interpolate and the precomp Hc will equal the Ho if your assumed position is your actual position and you make allowances for coriolis, etc. If you then go down track a given time and distance and compute another Hc, the difference should be the total motions, right? Now compare them to the traditional motions. Try this several times with different bodies and you will be convinced. The mathematical expression used, 15 COS LAT SIN Zn is just not adequate.

How gross is the error? I did six precomps straight from the H.O. 249 Vol III for a given LHA, day, and place and found .23, .36, 1.2, 1.6, .4, and .1 nm per minute error. Therefore, the error extends from 1.2 to 19.2 miles induced error on a 12 minute shot!

Now that you are properly alarmed, let's separate the various factors involved and examine them individually. The greatest portion of the error can be the use of the motion of the body equation. Why do I say "can be?" Because this problem is magnified by bodies in transit. A body with a Zn near 090/270 will not produce the horrendous errors mentioned earlier. The equation for motion of the body is only accurate instantaneously, which is to say right now, or right then, but not both. For one minute it is excellent. It can be multiplied times four with only minimal induced error ($\pm$ one nm). But any attempt to extend the equation beyond four minutes creates the problems mentioned earlier. The Mather publication "Day Celestial Student Workbook," Sep '71, has a warning on page 3-6 associated with extrapolating the motion equation. More mathematically, the equation is non-linear. The motions 12 minutes before fix time do not equal the motions 12 minutes after fix time. Also, two times the four minute motion does not equal the total eight minute motions. There is no easy adjustment or trick to use, nor is there a correct equation as yet. The fundamental motion of body equation simply does not allow us the luxury of a changing Zn, a changing latitude, and a changing LHA. All H.O. 249 tables, calculators, and MB-4s rely on an equation which we, by technique, use incorrectly in a common 12-8-4 three body fix.

FOR THOSE MOTIONS!

Captain Gary C. Eickmeier, 2 BMW Navigation Officer, Barksdale AFB, LA, was kind enough to provide the extract from the Student Workbook and was quick to critique some less accurate statements in my initial draft regarding the use of the motion of the body equation. He also provided explanations and clarification on two other related problems I had overlooked.

The cumulative error of precomping a shot for one point, but shooting it earlier or later elsewhere, has two other distinct components. First, a cel LOP is not a straight line, though we do plot it as such. AFM 51-40 warns against plotting straight line LOPs when within 4° of the subpoint, but neglects to tell us of the inaccuracies induced when we shoot early and plot the arc (as a straight line) from a precomputed Zn. Again, a body in transit is suspect, and the more perpendicular to the Zn we fly, the greater the induced error across a given time period. A good equation for this error is:

$$\text{Error} = \frac{\Delta Zn}{2} \times \frac{\text{Distance between assumed pos and actual}}{57.3} \times \text{Sin Rel Zn}$$

Δ Zn is the change in the Zn. How big is the error? Typical case of 450 KGS for 12 minutes, ΔZn = 3°, and the rel Zn = 90° is about 2.35 nm error. It decreases to 1.17 nm at rel Zn = 45°, and is equal to zero with a speed line with rel Zn = 0. Obviously, if Δ Zn increased to 6 or more degrees, as in a body in transit, the error would double. (See Figure 1.)

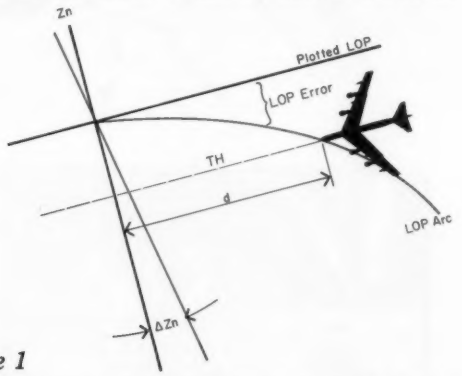


Figure 1

Next, the actual observation, viewed along the Zn, cannot be plotted along the precomp Zn without introducing an error. Mathematically, Error = Tan ΔZn x (distance between assumed position and actual position).

Again, how big is the error? When the distance between an assumed position and the actual position is 45 miles (not unreasonable at 450 KGS for 6 minutes) and ΔZn is again 3°, the error is again 2.35 nm. Increasing ΔZn to 6° (as near transit) and increasing the distance to 90 nm (as for a twelve early shot), produced an error of 9.45 nm.

So we have three contributive problems, all participating in threatening the classic 12-8-4 shooting technique:

1. Equation limitation error
2. Arc error
3. Plotting error

Equation limitation error and arc error always move the LOP away from the subpoint. Whereas the plotting error moves the LOP away from the subpoint if you are westbound, but towards the subpoint if your course is eastbound. (See Figure 2.)

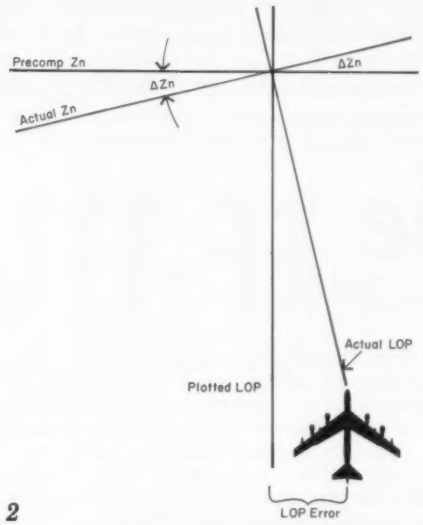


Figure 2

So what are the variables and how do we avoid them? Obviously a body near transit (large ΔZn) is to be avoided, as is flying westbound (plotting error) or observing bodies off the wing (large rel Zn). Be sure to avoid any celestial body with a high Ho (arc error) and select only stars, etc., with real motions very close to the motion table (equation limitation error).

If you can find anything left in the skies, you probably made a mistake. Quite obviously, all of these problems occur only when a shot is completed early (or late) and "adjusted" to another time. The lesson to learn is that it is fallacious to assume we can adjust a shot at all.

All three errors are a function of ΔZn, which can be computed only by solving two precomps (where the observation actually occurred and where you attempt to plot the LOP) and subtracting Zns to determine ΔZn. Distance between actual and assumed position can be measured by plotting and measuring or relying on a groundspeed against time for each LOP. Actual motion of the body can be resolved only by accomplishing two precomps, one at the observation point and another at the assumed position and subtracting the Hcs, then subtract all the aforementioned variables: arc error, plotting error, motion of the observer, and maybe one or two others I've missed. Now that we've finished the first LOP, we have two more to complete our 12-8-4 fix.

Of course, we can always change our techniques to eliminate the substantial errors necessitated by the 12-8-4 procedure. Though I was facetious previously, the attempt was to describe, in the extreme, the impossibility of adequately adjusting an LOP shot before or after fix time. Frankly, the magnitude of the error demands either a reasonable and workable solution or a change in procedures. As no solution is in the morning sky, we must avoid using the 12-8-4 fixing technique in favor of a method that does not promote the errors discussed. The secret is on-time or nearly on time, (±4 minutes) shots. Here are some suggestions:

1. Three LHA.
2. Two star, bracketing around an on-time shot.
3. Three star, using a standard four minute motion adjustment with the middle shot on-time.
4. Your own method—Good Luck!

Postscript: How did this ever happen? Years ago the printer of the H.O. 249 tables apparently left out a caution to the user not to extrapolate the motion tables. Three-star 12-8-4 was developed to meet the pacing requirements of faster aircraft. Awareness of the limitations seems to have passed from common knowledge to fairy tale with the passage of time.

A graduate of the University of Hawaii, Manoa Campus, Capt Runyan has a BS degree in Geology/Geophysics. He was commissioned through ROTC in 1974, and completed UNT in 1976, followed by CCTS at Castle AFB. Capt Runyan presently serves as a KC-135 navigator assigned to the 11 AREFS, Altus AFB.

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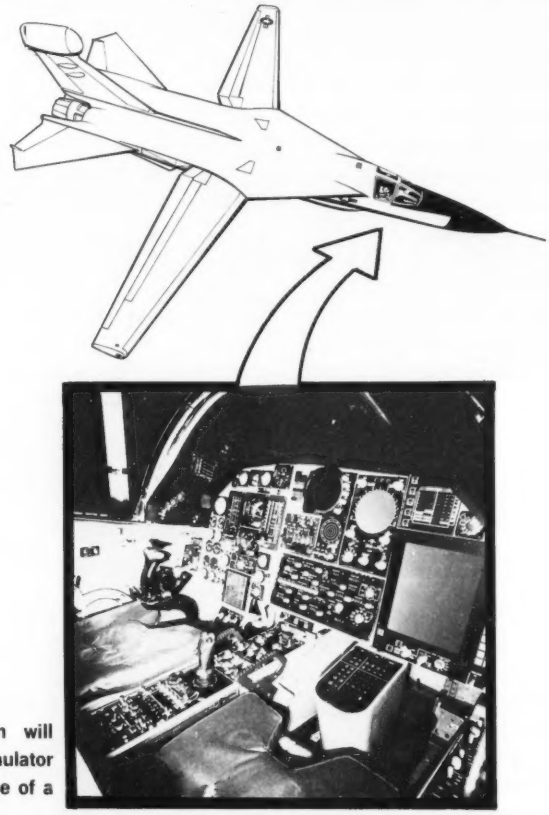
The EF-111A

The EF-111A Tactical Jamming System is the nation's most advanced electronic warfare aircraft. As a replacement for TAC's EB-66, this aircraft combines the speed and range of its F-111 airframe with the superior electronic warfare capability of the ALQ-99 electronic jamming subsystem (JSS). The aircraft's operating envelope is in excess of Mach 2.1 at altitudes up to 50,000 feet and Mach 1.4 on the deck with a large fuel capacity of 33,500 pounds. This combination of speed and range gives the EF-111A a variety of mission capabilities. It can jam enemy radar monitoring from a standoff position miles from enemy territory by setting up an electronic barrier, or penetrate enemy airspace to escort tactical aircraft providing close air support. The EF-111A's jamming functions are managed by an Electronic Warfare Officer who controls both active and passive equipment through on-board computer management. In addition, the preflight programming of the computer with known emitters allows the EWO to concentrate on new and more urgent threat radars. The EF-111A is now completing follow-on testing and evaluation at Mountain Home AFB. Delivery of the first production aircraft is currently scheduled for mid-1980 and USAF's full programmed purchase is slated for mid-1982.



Right seat configuration will closely resemble this simulator version—note the absence of a flight control stick.

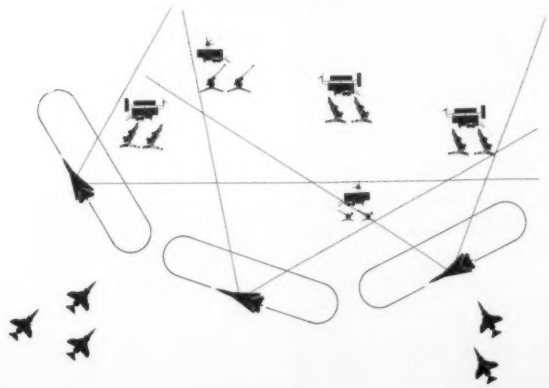
The SCORE

The statistics below concerning navigators and pilots in operational flying command positions were compiled by HQ AFMPC at the end of the third quarter of FY79. Similar statistics for Wing ADO, DO, CV, and CC positions were not available.

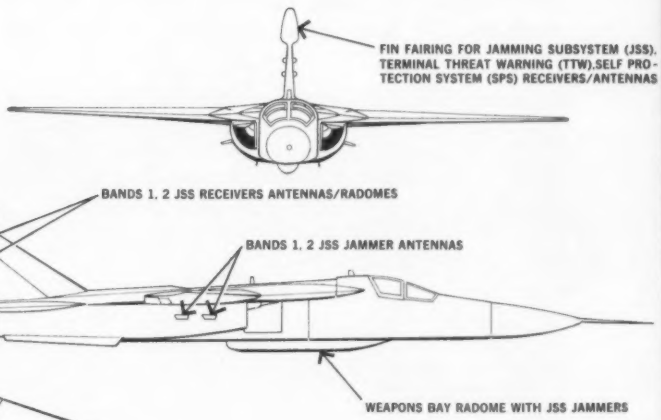
	FLIGHT COMMANDER		OPERATIONS OFFICER		SQUADRON COMMANDER	
MAJCOM	NAV	PILOT	NAV	PILOT	NAV	PILOT
ADC	1	3	0	1	0	1
AAC	0	8	0	2	0	2
PACAF	9	43	3	12	2	13
TAC	37	171	6	47	5	48
USAFE	21	59	5	18	2	21
TAF	68	284	14	80	9	85
SAC	3	181	4	64	1	67
MAC	—	—	1	45	1	45
TOTAL	71	465	19	189	11	197

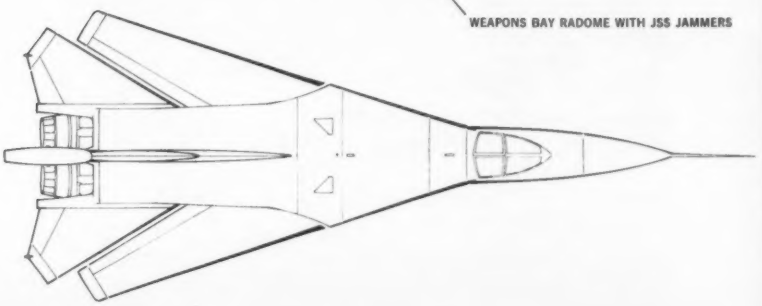
NOTES 1. Nav UE aircraft
2. SAC flight commander positions established at end FY78
3. MAC flying structure not by flights

Penetration/Escort



Barrier/Standoff


FIN FAIRING FOR JAMMING SUBSYSTEM (JSS), TERMINAL THREAT WARNING (TTW),SELF PROTECTION SYSTEM (SPS) RECEIVERS/ANTENNAS
BANDS 1, 2 JSS RECEIVERS ANTENNAS/RADOMES
BANDS 1, 2 JSS JAMMER ANTENNAS
WEAPONS BAY RADOME WITH JSS JAMMERS



SRAM PROGRAM

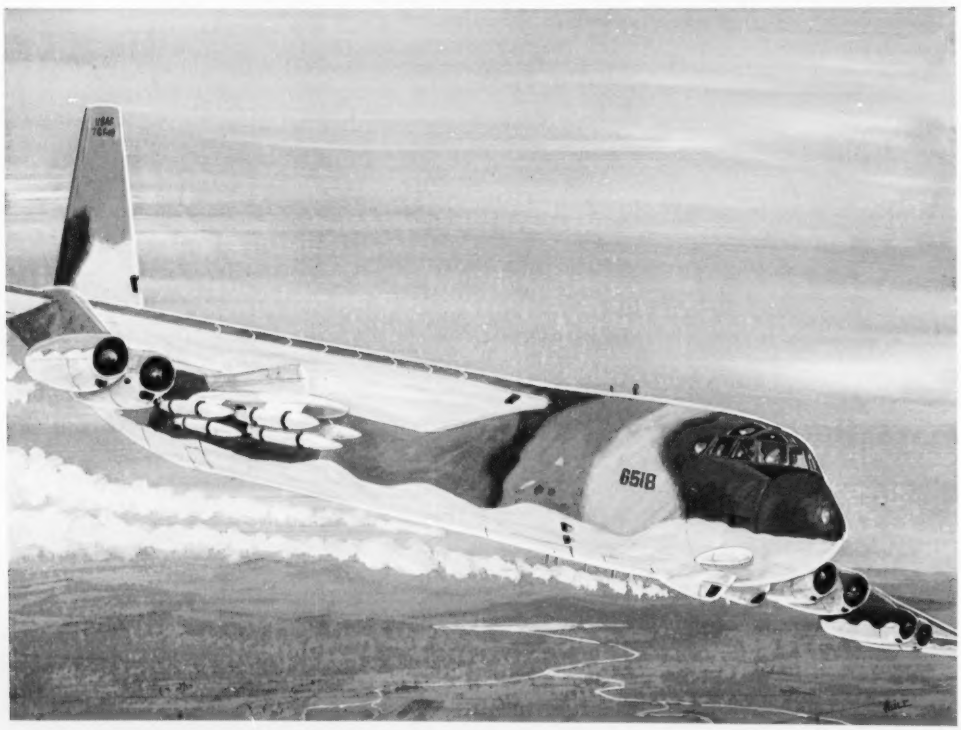
Captain George J. FERREN
319 BMW/DONB
Grand Forks AFB, ND

Basic to the results of successful Short Range Attack Missile (SRAM) programming, as in any operation, is the quality of maintenance. Without the efforts of dedicated, professional maintenance people, any endeavor by operations to produce a winner is an exercise in futility. Here at the 319th Bomb Wing we are fortunate to have a cadre of true professionals that consistently give us the quality demanded. Their long hours of extra effort were a key factor in our outstanding performance in last year's (1978) Giant Voice competition and enabled us to win the Dougherty Trophy for best SRAM in SAC (includes both B-52 and FB-111).

Without doubt the most important factor in SRAM programming is the quality of the Bombing-Navigation Set (BNS) inputs. Look through any set of maintenance records; the best Bomb Nav sets produce the best SRAM time and time again. SRAM is not a magic box; it's a computer which must have accurate inputs. By BNS inputs we mean heading, velocity, and fix updates. Of the three, heading is the least important (except when using an offset). Although good Doppler velocities are an essential part of system alignment, the most important is fix-to-fix updates.

In our competition plan of attack each enroute fix was "hand massaged." Every fix coordinate was a precision fix measured by either the Defense Mapping Agency Aerospace Center (DMAAC) or the 544th Target Materials Squadron (TMS). These sources are very important for daily training and ORIs, as well as for competition. First of all, they provide an extremely accurate coordinate source. Secondly, they provide a vertical photo of the area from which a radar pattern can be predicted.

For a point to be selected it must "show" when needed. Other factors to be considered are terrain masking, size of the structure, composition, shape, and axis of attack. Secondly, it must be prominent so there is no doubt where to put the crosshairs. The north corner of a round house in a marshalling yard certainly will provide an excellent radar return, but where would one aim if the marshalling yard is in a highly industrialized portion of town? Moreover, a marshalling yard's radar signature will vary depending on the number of trains there at the time of the fix.



MING

The measured point is not necessarily the best aiming point in the area. A radar prediction of the area is important in order to determine what shape the returns will take and which structures may split off from the rest. To do this, a knowledge of radar inherent errors is a must. The scope errors we are referring to are beam width, spot size, and pulse length.

Beam width error is a function of the width of the radar beam. The width of a beam in a B-52 ASQ-38 radar is 1½°. The error results because the return begins to paint one-half the beam width prior to when the center of the beam reaches the return and finishes painting one-half the beam width after the center of the beam passes. The actual value of the error varies and is dependent on the distance from aircraft to aiming point. For a 1½° beam, the error is 160′ per mile to the aiming point. One-half of this error is applied to each side of the return perpendicular to the look angle at fix time.

Pulse length error is a function of pulse width or duration of radar pulse. As such, it is dependent on range/target scale settings because they cause the radar operating characteristics to change from one-fourth microseconds (μs) to 1 μs . A 1 μs pulse duration is translated to 490′ on the radar scope. Therefore, a ¼ μs pulse width would yield a pulse length error of 120′. This error elongates the return parallel to the axis of attack.

Spot size error is a physical characteristic of the cathode ray tube and is a direct function of the range selected. The physical dimension of spot size error on the face of the scope is constant. Therefore, the smaller the range selected, the less the value represented by spot size error. The value is computed by multiplying 22′ times the target scale.

As you will agree, many factors must be considered to construct a true prediction. First, and most important, is the range at which the prediction is to be done. Once the optimum range is decided all other factors, such as axis of attack, range settings and modes, are derived from the aircraft to aiming point distance.

From the radar pattern, determine the best mix of simplicity in aiming versus precision. For example, one high altitude fix we used was a feedlot composed of numerous structures. The measured coordinates were to the southwesternmost building in the complex. Due to the altitude and axis of attack, this point would have been a very ambiguous aiming point. A better point was the center of the complex. Precision was maintained because the complex was relatively compact and because the inherent error overlap caused the complex shape to stay constant until after passing through a certain critical axis of attack. Afterwards, the complex popcorned into numerous small unidentifiable returns.

Now the problem is how to determine the coordinates of the new aiming point. First, we must determine a reference scale for measuring in feet on the photo. In this case, there was a small bridge on the photograph. Upon referencing the 200 series Air Target Chart it was discovered that the length of the bridge was annotated. That bridge now becomes our reference scale. With this bridge we can use proportions to determine the distance in feet north and east between the measured point and the new aiming point. These north and east components are then converted to arc minutes of latitude and longitude respectively using SACM 50-23, Tables for Computation of Offset Distances. These arc minutes of latitude and longitude are then added or subtracted, as appropriate, to the latitude and longitude of the measured point.

The techniques for determining a proportional scale for the photograph are numerous. When looking at vertical photos, especially in the midwest, remember that section lines run north/south and east/west and are one statute mile square. Also, city blocks are laid out in true north and usually a city block measures 320′.

A racetrack located in a school complex will be one-fourth statute mile in circumference. Sometimes sizes of buildings or diameters of tanks are specified in the point descriptions issued by DMAAC or the 544 TMS. At times, two measured points are located on the same photo. It is then a simple process to compute the feet and azimuth from one to the other. As you can see, the methods are numerous and are only limited by one's imagination.

Another important consideration during SRAM programming is fix pacing. "Quick fixing," or taking fixes less than 15 minutes apart, is not a recommended procedure. Not only was the SRAM system not designed to properly analyze these rapid inputs but quality of scope tuning and aiming may deteriorate to an unacceptable level due to crew workload. Ideally, the fix pacing schedule would be one fix every 30 to 45 minutes or one during each half of a Schuler cycle. This is not critical, but desirable. The staff and crews studied each fix point for possible conflicts with other mission requirements. Any conflict was resolved prior to the flight. Never slam a fix into the system simply to satisfy a requirement.

This brings us to the point of SRAM as a bombing aid. SRAM Carrier Aircraft Equipment (CAE) has been a tremendous boon to the navigational and bombing reliability of the B-52G and H models. This viable system should be fully integrated into a system's confirmation check on a bomb run. However, the exclusive reliance of SRAM as a panacea for aiming point misidentification is a misuse of the system. The tactic of fixing 5-7 minutes apart between the IP and the launch point is incompatible with quality CAE results. First of all, crew workload is extreme approaching the initial point. Systems are being set up for bombing the target, checklists are being accomplished and the RN's thoughts are to the timing initiation point and the ensuing target area, while the navigator is concerned with IP alignment and final speed adjustments. This is not the time to concentrate on quality checkpoint fixing. Secondly, the target will be your most precise fix because more time has been put into its preparation and study. However, because of the characteristics of the SRAM's navigational model, more commonly known as the Kahlman filter, the SRAM system will accept only 50% of the information of the second fix (if it accepts it at all) since a fix was inserted only 5 minutes prior. Our game plan called for a fix 2-5 minutes prior to penetration into the low level route and then one fix at each target area only.

This brings us to the most critical input of all—the quality and timing of the launch point fix. The distance of the offset aiming point used for final aiming to the AOU (automated offset unit) reference point must be minimal (preferably zero). The time from launch point fix insertion to launch must also be minimal. These two tactics are not mutually exclusive and can be employed together with careful planning. During an evaluation type mission, whether it be an ORI or Giant Voice, almost all the SRAM launches occur immediately following the last bomb of a bombing sequence. This forces the tactic of using a target as a launch point fix. A competition complicates matters since the target coordinates are adjusted for the hit patterns of the aircraft. For a SRAM fix in conjunction with a bombing target, not only must the hit pattern be established, but the reason for this pattern must also be known. If a bombing target's coordinates are moved several hundred feet because of the aircraft's ballistics computations, one would also have to move the SRAM launch point fix to those same coordinates. In this case one would not be "lying" to the SRAM. However, if the aircraft is ranging in error due to a ranging computation, boresight, or AOU static error, then the SRAM must see the original target coordinates. The analysis of these errors is a topic in itself and will be discussed later.

All this careful, analytical work is absolutely worthless without professional operators at the controls. The navigators must know the procedures "cold." Navigators must be on track, radar navigators must use the proper range selections and they must know the art of scope tuning. The nav team must be disciplined enough to know what range/axis of attack to make their final aiming and they must adjust to actual in-flight conditions. In other words, the bottom line is the aircrew's system knowledge, the amount of time spent in mission planning, and the in-flight execution of the game plan.

Capt Ferren graduated from the University of Massachusetts at Amherst in 1974. Commissioned through ROTC, he completed navigator training and was then assigned to Wright-Patterson AFB as a radar navigator in the B-52H. Next came an Arc Light tour in the B-52D, followed by assignment to Grand Forks AFB in July 1975 as a radar navigator. In 1977, he attended CFIC at Castle AFB. Capt Ferren presently serves as Wing Missile Operations Officer, Grand Forks AFB.

SENIOR NAVIGATOR OF THE UNIT

Editor's Note: This article, which first appeared in the December 1961 issue of THE NAVIGATOR, is a translation from Herald of the Air Fleet, a monthly joural of the Soviet Air Force published by the Military Publishing House, Ministry of Defense, USSR.

Every effort has been made to provide as accurate a translation as practicable. Soviet propaganda has not been deleted, as it is felt that such deletion could reduce the value of the translation to some extent. Political and technical phraseology of the original text has been adhered to in order to avoid possible distortion of information.

This article was selected for inclusion in THE NAVIGATOR in the belief that our readers would welcome information which permitted some insight as to the environment and training of their Soviet counterparts. Discernible amidst the glowing rhetoric are interesting references to academic and flying training, airborne radar and computer operation, radar bomb scoring, and functions comparable to those of our standardization boards and combat evaluation exercises.

Permission to reproduce the article was obtained from the Foreign Technology Division, Air Force Systems Command.

Major General of the Air Force
N. Ya. KONDRAT'YEV
Military Navigator First Class

Work was in full swing at the airfield—the crews were preparing for a critical night flight with check exercises in bombing. Preparations went on rhythmically and with outward calm, and each did his usual work. After all, similar flights had been carried out more than once in the unit and always successfully enough. And yet the crew members were nervous.

The disciplined and outwardly calm senior navigator of the unit, Trifon Vasil'yevich Petrenko, was perhaps most nervous of all. And this was understandable; the basic elements subject to checking were the precision of navigation and accuracy of bombing, i.e., exactly those things for which he as a unit navigator bore personal responsibility. It was Major Petrenko who, according to his official duty, had to teach the navigators and pilots and train them for such flights. And for this, it was necessary to work properly with them for a long period of time. And he worked conscientiously and with love, transferring to them his knowledge, his navigator's and his practical experience.

We happened to visit the class which Major Petrenko conducted with the navigators of the first squadron. It was devoted to preparation for the forthcoming flights to bomb with the radar sight. One could feel that it was conducted by a mature methodologist. He plainly and clearly spoke about the peculiarities of preparing the sight for bombing under various conditions. Actually, the subject itself was not new to his students. After all, each one of them had already prepared for flights many times and had carried out bombing with a radar sight. And yet the instructor set up his lesson in such a manner that it was received with interest by all the navigators.

He spoke of shortcomings when the sight is employed, gave a profound theoretical analysis and evaluation; indicated how they must prepare for flight in order to preclude these shortcomings and carry out bombing successfully. It would be much simpler to conduct a class on a similar subject in a school; there are approved lecture outlines there, a multitude of training aids and an established methodology. Conditions are entirely different in a unit. The basic materials for study here are the personal observations by the commander of the work of subordinates during preparation for flight, when they practice on training apparatus and in the course of bombing. The basic questions for study are the shortcomings uncovered recently by checking on flight readiness and results in bombing. Having utilized all this material, Petrenko managed to give the navigators of the crews all that was necessary.

However instructive theoretical study may be, still it gives mere knowledge. And in order to carry out a combat training mission successfully, one requires habits and skills as well. Trifon Vasil'yevich, who is an experienced first-class navigator, knows this well and this is why he allots much time for training practice. He strives to see that each navigator masters well the procedure of operating the apparatus as he comes out on a target and at the moment of sighting, and learns to operate the various control handles precisely and smoothly. Of course, he himself is unable to conduct training practice with all the aircraft navigators. But he has reliable assistants: the navigators of the squadrons and elements. And it is his job to check on them. Sometimes he himself checks on certain navigators at random, and shows them how they must practice the most complicated elements of lateral aiming and synchronization. Petrenko is always concerned that training be conducted

precisely, rhythmically, and effectively, and that each minute of training time is of definite benefit to the navigators.

They were preparing for the forthcoming flight very thoroughly. Each knew what he had to do and when and how to do it. This was confirmed by checking the flight readiness of the crews individually.

Before taking off, each could spare a little time in order to practice operating the navigational and bombing devices in the aircraft cockpit, to tune and calibrate the sight and set the initial data in on the instruments. This time also was expended very carefully. Each navigator tried to do all that was possible on the ground, thus maximally facilitating and simplifying his work in flight.

Petrenko personally checked on the navigators who flew with him in the same combat formation and was satisfied with their preparation. He also carefully prepared himself for flight, since he knew well that it would not be easy for the leader in such a critical flight. The success of carrying out the mission by all the group much depended on the leader.

We arrived at the bombing range a few minutes before the start of bombing. While discussing the details of the mission, not all were sure that the crews would achieve high scores. It was particularly feared that they would not come out on the prescribed targets on time. The fact is that the time for coming out on the target, which was recorded according to the moment of bomb impact, was given to the crews before takeoff. Therefore, each of them had to calculate this time by taking into account the flight route distance, the flight speed, the time involved in climbing, the direction and velocity of the wind at various altitudes, the time involved in turning at the turning points, and other navigational elements. It was also necessary to take into account the time required for fighter, missile, and AA evasion maneuvers. As for night flights under adverse weather conditions, we will frankly say that the task is not easy, especially since many of the time factors may only be predicted before takeoff and are only actually determined in the air. And, supposing there will not be enough time for an AA evasion maneuver, this will have to be compensated for by increasing the speed or reducing the flight route. And an increase in ground speed by getting into a tail jet stream must be reduced correspondingly at the expense of reducing the air speed or extending the flight route.

Evaluation norms for navigation are rather stiff. In order to obtain a high evaluation, it is necessary to take into account each kilometer, each second, and each angular degree, and introduce the necessary corrections in the flight regime. And what about the wind? Even the most precise measurement of it by meterologists will not correspond to the actual wind an hour after the measurement or some dozens of kilometers away from the place of measurement. Only a measurement of the actual wind aloft can give a true picture of the ground speed, the drift angle, and thus the correctness of carrying out the timing of the flight as well.

This difficult task becomes naturally more complicated for a crew occupying the lead position in the column formation of night bombers. After all, they cannot count on the fact that they will be able to check their computations by comparing them with the data of other crews. Being the leaders, they are obliged to depend in flight only on themselves and on the integrated application of various navigational facilities regarding the correctness of computations.

It is very difficult to find a target and come out on it in a night flight, both above and in the clouds. If the crews who have a range-finding system aboard reach comparatively easily the bomb-release point after coming out of the prescribed orbit and with the aid of a computer, then the crews having a radar sight must apply much effort and skill to distinguish the complex combination of radar check points on the terrain, identify the prescribed target by their relative position, and come out on it from the prescribed direction.

Our thoughts on the difficulties of the flight that had started were interrupted by the loudspeaker: "Ruby, this is Falcon 13, request approach."

The flight controller permitted approach to the bombing range. The blip showing the position of the aircraft tracked by the bombing range radar appeared on the controller's board. It was still impossible to tell by it how precisely the crew would come out on the target, but it was already possible to assert that there were no gross errors in the procedure.

They still had to come out at the initial point of the run and find the assigned target on the radar sight scope among a multitude of radar blips. On a bomb run it is necessary to aim at the target, to perform lateral aiming and synchronization, and to drop the bombs after permission to bomb has been granted. All this complex process must be carried out quickly and precisely at a high speed.

Time is a very important factor in flight and it is indeed because of disregarding time that pilots and navigators of little experience most often make errors in navigation. This does not mean that one must hurry, for example, in determining

the bearing or in making any computation. No, everything should be done as prescribed—calmly, rhythmically, without losing, however, track of time.

At the bombing range, the moment of coming out on the target is recorded according to the bomb impact which practically corresponds to the aircraft's position over the target at the moment of impact; and, being at the command post of the bombing range, we were waiting for this impact, while looking at the second hand of the stopwatch.

And here was the impact. A glance at the stopwatch showed that the hand pointed to zero. Excellent. Not only excellent but simply remarkable. The crew of Zlobin and Petrenko had come out on the target exactly on time. This does not often happen even with outstanding crews.

We were sincerely overjoyed at such high precision in navigation. But this is only one aspect of a flight. There is another aspect that is more critical and determines the purpose of the flight—the bombing. Some time went by and the plotter marked the point of bomb impact according to the data of tower scorings. Excellent! As the measurements showed afterwards, Trifon Vasil'yevich Petrenko and his commander had the best results for the night in bombing as well (an example worthy of imitation!) although the remaining crews also carried out the mission with "good" and "excellent" marks.

When the results of the mission were summed up, many good words were said in favor of the lead crew. The well-earned praise was pleasant not only to the deserving men themselves, but also to their commanders and subordinates: this was the result of much work in studying theory, mastering aircraft equipment, and cultivating a sense of responsibility for the work assigned.

Automatic devices facilitate the work of the navigator in many respects; however, with present-day flight speeds, especially under adverse weather conditions and at night, success in navigation and bombing is mainly determined by the navigator's preparation for flight, by his skill and experience. It is therefore not easy to learn the business of navigation at the Academy, but it is even more difficult to study at the Academy as an extension student when one has to combine intensive flight work with no less intensive home study.

Officer Petrenko has passed along this difficult road. Beginning to study at the Academy as an extension student while still an element navigator, he successfully mastered the course of academic studies and managed to organize his study in such a manner that it not only did not interfere with his work but even helped it. During the period of study he rose to squadron navigator. Upon graduating from the Academy, T. V. Petrenko was appointed deputy senior navigator of the unit and this is the third year that he has been in charge of the navigational service. The knowledge acquired at the Academy in physics, higher mathematics, the theory of navigation and bombing and his accumulated experience enable him to organize classes with the flight personnel on navigation and bombing skillfully and to conduct them interestingly, to be an exemplary performer of the navigator's duties, and to study successfully and achieve good results in complex types of combat training.

T. V. Petrenko conducts extensive work in training the flight personnel in navigation, in inculcating in them the skills of navigation and bombing and mastering new aircraft equipment.

Such types of combat training as the tactical bombing of actual objectives, maneuvering along the flight route to evade "enemy" PVO (antiaircraft defense) action, are complex in their organization, execution, and control. It is, however, necessary to master them and approximate the conditions of carrying out training flights to the possible actual ones; and here, too, a great role belongs to the senior navigator of the unit who is the principal organizer of these complex types of combat training.

The pilots and navigators are not only interested in the urgent tasks of combat training. They listen with pleasure to the lectures on the prospects of developing facilities and methods of navigation, of the laws of ballistics, missile flights, the structure of the universe, cosmic speeds and flights in space. Yet, who but the senior navigator of the unit can deliver such lectures to the flight personnel? And for this he must constantly enlarge his knowledge, keep abreast of recent achievements in science and technology connected with the business of navigation, possess a feeling for the new, develop and cultivate it in his subordinates. There are many interesting things also in technology, science, art and literature. But one must know how to select what is most important and necessary for extending one's mental horizon and understanding what is going on.

And then it is not enough to know and be able to perform one's work and even teach it to others. It is necessary to kindle a spark in men, arouse their activity, interest and ambitious creative perception of all that is in any degree connected with their specialty. Trifon Vasil'yevich and the navigators of the squadrons and elements have managed to see that the business of navigation becomes one of the most respected in the unit.

THE RESERVE TANKER NAVIGATOR

Captain Richard A. STEWART
336 AREFS
March AFB, CA

"Pilot—Nav, prepare for grid entry checklist." Sound familiar? A typical scene on an everyday SAC navigation leg? Well, almost!

The big difference here is that the pilot is the owner of three liquor stores, the copilot, an airline flight engineer, the navigator, an engineer for an aircraft company, and the boom operator, a civilian flying instructor. All former active duty Air Force personnel, this crew is now actively participating in the Air Force Reserve program.

Many navigators probably wonder who these Reservists are, how their program differs from active duty, and what life is like as a "part-timer" in national defense.

Our organization, the 336th Air Refueling Squadron, is the operational element of the 452d Air Refueling Wing, Air Force Reserve, located at March AFB. Along with other subordinate units of the Wing, the 931st Air Refueling Group (AFRES), Grissom AFB, and the 940th Air Refueling Group (AFRES), Mather AFB, we are currently the only SAC-gained units in AFRES.

The Air Reserve Forces of today are involved in the entire spectrum of Air Force flying activities. "Weekend warrior" is a totally inappropriate term as you will see. On almost any given day or night, somewhere there are AFRES aircrew members flying a mission in a C-7, C-123, C-9, C-130, C-141, C-5A, A-37, F-4, F-105, KC-135, AC-130, or an AFRES helicopter. No matter what their civilian occupation, these men and women have one thing in common—they are all Reservists.

There are two types of Reserve flying organizations, those "owned" and managed by the Air Force Reserve (in peacetime) and AFRES associate units. In associate units, the aircrews, maintenance, and other key personnel are Reservists, but they integrate with their active duty counterparts and fly and maintain aircraft of the active force.

The 336th is a totally independent, non-Associate Reserve unit organized along the same lines as an active unit, flying and maintaining its own aircraft. The Squadron's key sections are manned 40 hours a week by Air Reserve Technicians (ARTs). These personnel are uniformed Civil Service employees and Reservists who form a "core of expertise" and provide continuity to keep the Reserve unit functioning on a day-to-day basis. Most are highly experienced instructors in their fields.

The rest of the unit's personnel are the part-timers, sometimes called "pure Reservists." They may be airline employees, engineers, real estate brokers, chiropractors, firemen, or whatever, but when they show up to fly a mission you can bet they are trained, ready, and frankly, good!

Since most of our Reserve navigators have active duty experience, the average navigator is relatively "high time." The average nav in the 336th has over 2,000 hours in the KC-135; many have logged over 4,000 hours total flying time. To a lot of today's active duty navs, the Reserve KC-135 navigator is an "old head" (though to those under 30 this title is not becoming!). It is likely the nav has actually participated in combat in Southeast Asia. Most flew numerous Young Tiger Tanker Task Force sorties in SEA, and all have global flying experience.

So, how do a bunch of old head, high time civilians keep current and qualified? By flying, flying, and more flying! These dedicated professionals believe in seeing to it that SAC's extensive training requirements are completed or exceeded. Ground training is accomplished during the one weekend a month when the entire unit meets. This is called the "UTA" or Unit Training Assembly.

Classes that are normally spread out over 20 working days of active duty are consolidated and given in rapid-fire succession during these intensive 16-hour meetings each month. While

these Reserve navs usually accomplish replots while pulling SAC Alert Duty (alongside the active duty force), check ride critiques are given during the UTA. Other items are also accomplished, such as updating flight publications, aircrew generation practice, critiques of ORIs passed, etc.

Scheduling is completed through a truly all-volunteer concept. The navs receive a monthly "bid" sheet on which they may select the flights and cross-country trips for which they are available, along with whatever alert time can be put in. Schedules are made up entirely from a crew's voluntary availability.

Due to the nature of our unit, there are no integral ("hard") crews as such. Each crew member will probably fly with every other crew member at least once a year. This flexible crew scheduling requires a very high degree of flight crew standardization. Such non-hard crew flying is actually not as difficult as some would believe, when you realize that most Reservists are long-term members of a unit with very little turnover in personnel.

After a while each crew member becomes familiar with one another's techniques and in-flight methods, making crew coordination much easier. Most of our navs prefer flying with a variety of crew members and believe that it sharpens coordination skills.

Reserve navigators may also assist the various squadron or wing sections throughout the year, as full-time manning of the DOX, DOC, OPS, and DOTN sections is limited. This broadens a nav's operations knowledge while assisting the unit in accomplishing its mission. Many eagerly accept this challenge and appreciate the responsibility of taking an active part in staff functions.

An important characteristic of the Reserve program is its flexibility. Navs can work at their civilian jobs all week and still meet their Reserve flying commitments. Most employers encourage Reserve participation, and the navigators plan their availability so as not to interfere with their civilian work schedules. Cross-country trips, for example, are usually planned to allow a crew member to work at his or her civilian job, then report to fly, and complete a trip or training flight with minimum disruption on the crew member's civilian routine.

The key factor here is motivation. If a Reserve crew member is not motivated to fly a mission, even after completing rest time requirements following a day of work at a civilian job, the Reserve program could not be successful. One important thought: Reservists are not obligated, they are—in the truest sense of the word—volunteers.

When the nav arrives at the squadron for a flight, the entire mission already has been planned. Air Reserve Technician navigators or other Reserve navigators, pulling training tours, have prepared the charts and mission plans well in advance of a crew's show time.

Since a crew may see its mission for the first time only a short period before the nav briefs it, the nav must study it intensely and present a concise briefing. For check rides, navs must accomplish their own mission planning.

Partly to keep the morale and interest level up, but mostly to maximize training benefits, many weekend cross-country trips are offered. Schedulers try to organize trips that are both enjoyable and highly productive (training-wise). An air refueling and nav leg can be very enjoyable if you will be spending the night in your old home town 2,000 miles away!

In August 1979, the 452d Air Refueling Wing and its subordinate units deployed to RAF Mildenhall, England, to augment the European Tanker Task Force. The 540 men and women involved represented a cross-section of those specialties needed to support operations in England.

Many of the Air Force Reservists were on their two-week annual active duty tour for training. All the personnel and their equipment were moved by 452d aircraft. The valuable experience gained by 452d navigators during this major deployment contributed to the unit's maintaining a high state of readiness.

Due to our unit's geographic location, most of our receivers on air refueling missions are non-SAC aircraft. We've refueled nearly every type of fighter along with the C-5, C-130, and the RC-135. This variety of air refuelings has helped our navigators maintain their proficiency and versatility.

We have participated in many tanker task force operations. Coronet Crane, Red Flag, Coronet Hawk, Volant Boom, and Eielson Tanker Task Force are examples of the many exercises and operations we've supported.

"Flying interesting missions really keeps our interest up," Captain Leonard Hardtke, a 336th Reserve navigator says. "Reservists don't mind going TDY for several days and flying every day because of the interesting places we visit. Most of us navs feel that much more can be learned on such trips since they are not just for training, but are also tactical and support important Air Force missions."

The 336th has a crew on SAC Alert 24 hours a day, 7 days a week throughout the year. Reserve alert differs from the active duty variety mostly in the flexibility of the crew scheduling. Navs can pick and choose changeover times, days, and frequency from such tours of duty available each month.

Reserve crew members' time on alert may be spent as they please within SAC's guidelines. Training is not usually conducted while a member is on alert, due to the highly flexible and free substitution-type of scheduling. This approach has actually resulted in a waiting list for alert duty!

One unique aspect of our missions is that they generally come under operational control of AFRES Headquarters, Robins AFB. If on a SAC special mission, task force, or other SAC-controlled mission, the AFRES crews must be familiar with more than one set of manuals and regulations.

The variety of navigational experience found in the 336th and other Reserve units generates many new ideas and concepts which are integrated into the overall management of the navigation program.

Standardization, testing, classes, handouts, and group discussion frequently reflect MAC, TAC, and ADC influence. Additionally, operations and staff functions can also benefit from the commercial airlines' operating procedures, as many of the crew members are employed by them.

Pay is a consideration with all Reservists, and it is a definite plus with our unit. A Reservist gets a day's (1/30 of an active duty month) pay for a day's work (or one flight). For alert duty, the crew member receives pay for both the days on duty and also for "standby duty," which is comparable to the active duty force's CCRR or "C^2."

In addition to the financial benefits, Reservists also have limited BX, commissary, and other benefits earned through their Reserve participation. All Reservists earn points creditable toward military retirement at age 60.

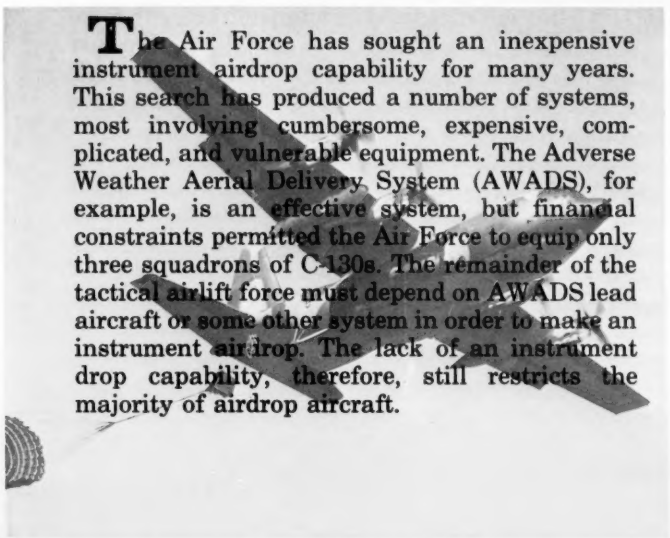
You should realize by now that there really isn't a great difference between an active duty navigator's job and that of a Reserve nav. Reserve navigators, like their active duty counterparts, are professionals—highly trained, motivated, and ready as part of the total force.

The Reservist plays an ever-increasing role in supporting active force tactical missions on a daily basis. The navigator's participation is vital for the continuing success of the Reserve program. These "Magellans of the sky" fly, train, go TDY, do PME, receive OERs, pull alert, and do it proudly—as navigators. The 336th accomplishes this as *The First and The Finest.*

Capt Stewart graduated from California State University, Northridge, and has a master's degree in Education from Northern Michigan University. After UNT, he was assigned to the KC-135 at K. I. Sawyer AFB, followed by a SEA tour in the EC-47 and CCTS instructor duty at Castle AFB. Capt Stewart is a Reserve Instructor Navigator with the 336 AREFS,March AFB.

INSTRUMENT AIRDROP CAPABILITY

Major Jay A. WEISS
HQ MAC/DOVN
Scott AFB, IL



The Air Force has sought an inexpensive instrument airdrop capability for many years. This search has produced a number of systems, most involving cumbersome, expensive, complicated, and vulnerable equipment. The Adverse Weather Aerial Delivery System (AWADS), for example, is an effective system, but financial constraints permitted the Air Force to equip only three squadrons of C-130s. The remainder of the tactical airlift force must depend on AWADS lead aircraft or some other system in order to make an instrument airdrop. The lack of an instrument drop capability, therefore, still restricts the majority of airdrop aircraft.

Little Rock AFB tactics and techniques personnel discovered a technique which may give most airlift aircraft an adverse weather drop capability with minimum expense in time, training, or dollars. The only requirements are that the aircraft be equippped with a UHF radio with direction finding capability and radar which can receive an X-band radar beacon. Since most C-130, C-141, and C-5 aircraft meet these restrictions, the proposed technique should prove useful to most airdrop aircraft.

The technique requires a Combat Control Team (or other ground personnel) to find the Computed Air Release Point (CARP) exactly as they would

for a ground-marked release. Instead of marking it with lights or panels, however, they place a UHF beacon and radar beacon on the CARP. Little Rock AFB CCT members used an SST-181 radar beacon and a PRC-66 UHF/DF radio for the tests.

The beacons then give the aircrew an electronically marked release point to steer toward. This, in turn, allows the aircrew to focus attention on maneuvering the aircraft to a marked point, instead of attempting to compute and find an unmarked point in instrument weather conditions. The test aircrews used a C-130E equipped with an APN-59 radar and a UHF radio with DF capability.

The following procedures provide reliable results with this method: normal navigation is used to the slowdown point (7-12 nm from drop zone). After slowdown the pilot flies an "ADF final approach" at drop altitude, on drop zone magnetic course, using UHF/DF signals as a navaid. Meanwhile, the navigator monitors track and calls distance to CARP using a radar beacon return visible on the radar scope (both beacons are usable at slowdown, 500 to 1,000 feet AGL). At about one minute out, the UHF/DF needle begins to waiver, and the pilot relinquishes course guidance to the navigator, who gives small corrections to keep the radar beacon return tracking toward the scope center. The navigator then starts a stopwatch as the beacon return crosses the one (or two) mile range mark and calls release at expiration of time from hack to beacons. (Slant range and beacon delay computations are found in Chapter 6 of MACR 55-40.)

Drop scores were encouraging. Circular error average (CEA) for drops at 1,000 feet AGL was 100 yards (13 drops). CEA for drops at 500 feet was 38 yards (5 drops). Both pilot and navigator operated under simulated instrument conditions; the pilot used only instrument references and the navigator had the blackout curtain pulled. Some of the drops occurred at night on an unmarked drop zone.

Both CCT and aircrew personnel were enthusiastic about this method. CCT members stated that the run-ins were very stable and that load release occurred almost exactly overhead the beacons on each pass. CCT leaders were also impressed by the fact that it took less time and fewer personnel to set up a drop zone with beacons than with conventional panels or lights.

Aircrews stated that tracking was quite simple and that drops became routine after a few practice runs. Furthermore, one crew deliberately placed its aircraft 4-5 nm off course only 7 nm from the drop zone to see if the UHF/DF beacon would provide usable signals for a correction back to

centerline prior to drop. This crew accomplished the correction with no difficulties. The crews also stated that the UHF/DF and radar beacons provided mutual backup capability. With UHF/DF beacon inoperative, the run-in was more difficult, but still possible by observing radar beacon returns. With the radar beacon out, the release point was more difficult to determine, but still possible by observing station passage on the UHF/DF beacon.

In summary, the technique described in this article may provide an inexpensive instrument airdrop capability for most airlift aircraft. The author expanded the above description considerably in a paper completed in May '79, at the Air Command and Staff College. Copies of the study, complete with strengths, weaknesses, and recommendations concerning the proposed technique, were sent to each tactical and strategic airlift wing. The author invites interested navigators and other readers to offer feedback on its validity to wing, numbered Air Force, and major command contacts, as well as to THE NAVIGATOR.

Maj Weiss has a master's degree in Political Science. After UNT, he was assigned to the C-130 in the Philippines before instructor duty at Forbes AFB. At Little Rock AFB, he served in Stan/Eval and then as Tactics Officer. Maj Weiss now is an Evaluator in Stan/Eval, HQ MAC, Scott AFB.

The 2nd Annual USAF NAVIGATION SYMPOSIUM

Captain Stephen M. RAY
HQ USAFA/CWIN
USAF Academy, CO

Captain Robert J. SALLEE
HQ USAFA/CWIN
USAF Academy, CO

Do you feel that your career as an Air Force navigator is in jeopardy because of recent technological developments? Are you concerned about limited staff opportunities because of a rated officer "crunch?" If you are presently a nav in a C-141 or a "fighter-gator" in an F- 4, what is your destiny 10 years from now? These and many more questions and issues were discussed during the second annual USAF Navigation Symposium conducted at the Air Force Academy from 5-7 September.

The theme of the symposium was "Navigation in the 1980s." Various organizations and headquarters across the country sent navigators to the event: 30 officers traveled to the Academy, representing AFMPC, ATC, AFSC, HQ USAF, MAC, SAC, TAC, the AFRES, and the ANG. Special briefings by the MAJCOMs and other organizations set the stage for lively working groups established to discuss topics foremost on the minds of today's navigators. Working group sessions addressed navigation technology, navigator training, and navigator utilization and career development.

The beginning for an annual USAF Navigation Symposium occurred in September 1978. Under the leadership of Lt Col Jerry E. Singleton, former chief of the Academy Aviation Science Division, the concept was born for an annual event to examine pertinent navigation issues and the navigator career field.

This year's symposium benefited from broader participation than its predecessor, and many interesting and informative presentations were made. ATC briefed on the new "tailored approach" to Undergraduate Navigation Training which includes advanced training courses for navigators going to cargo, tanker, reconnaissance, and fighter assignments, as well as the traditional NBT and EWOT courses.

MAC, SAC, TAC, AFRES, and ANG briefers presented the outlook for navigator manning in their organizations into the 1980s. The message was loud and clear, particularly after an in-depth AFMPC briefing: requirements for navigators, bombardiers, electronic warfare officers, weapons system officers, instructors, staff officers, and flying commanders will offer viable navigator careers in the foreseeable future.

Technology briefings introduced symposium attendees to the use of and planning for operations in the next decade. The topics included the OMEGA system, the NAVSTAR Global Positioning System, future SAC systems, lessons learned from flight tests of the B-1, and specific navigation applications of the hand-held computer.

An evening panel discussion was also held with 100 cadets currently enrolled in the core Aviation Science course or serving as Cadet Aviation Instructors. The cadets were keenly interested in talking with professional aviators and the men and women of the Air Force Cadet Wing asked probing questions to expand their knowledge of operational flying duty and career opportunities. This aspect of the symposium is of particular value to the Academy since many cadets have limited opportunity to interact directly with operational navigators.

The final phase of the symposium was devoted to two professional working groups established to identify and discuss issues of general concern to all navigators. The intent was to provide a basis for future staff action to mutually support navigator professional development.

The following short paragraphs synopsize some of the generally agreed upon concerns and recommendations.

Annual Navigation Symposium. Recommend continuing the annual navigation symposium to provide an effective vehicle for joint command identification and resolution of problems and issues relative to navigator operations, training, professional development, manning, and retention.

Performance Rating Officials. Evaluating promotion potential and career counseling functions under the current OER system cannot be effectively performed when the rater is not senior to the ratee. Recommend steps be taken to alleviate present situations for company and field grade officers where the rating official is junior to the ratee, or a peer.

Command Navigator Rating. Recommend changing the current "Master Navigator" rating to "Command Navigator" to more accurately reflect the command role of the navigator in today's Air Force.

Common Rated Staff AFSC. Support review and adoption of the provisions recommended in the Title 10 Ad Hoc Committee Report of 21 November 1974 that: (1) a single AFSC be established for rated staff and supervisory positions which may be filled by either a pilot or navigator, and (2) all rated staff and supervisory

positions be examined with a view toward redesignating with the new AFSC those positions which do not require a specific rated skill.

In addition, other questions raised by individual attendees included: if projections call for a navigator shortfall in the active forces for the next six years and the ANG has an increasing requirement for navigators, what increases must be made in UNT production rates for effective force management? If MAC has delayed the drawdown of navigators from the C-141 and C-5 as briefed, what impact will this have on overall requirements during the next five years? Can a program be established with the FAA to reduce the volume of written and flight examinations for current navigators competing for an FAA rating to a scope similar to that required for current Air Force pilots competing for an FAA pilot rating? Does the USSR emphasis on acquiring two-seat fighters have implications for our long-range approach to tactical air warfare for the next generation of USAF fighters (the F-XXX) and for future navigator manning requirements?

These questions and many others remain unresolved. The purpose of the Symposium is to assemble professional navigators with a broad base of experience from all of the MAJCOMs to address issues such as these. Perhaps in this way, we can be even more effective in meeting our national defense needs in the years ahead, benefiting not only the Air Force as a whole, but also expanding the career opportunities for the USAF navigator. We'll need your help, so begin planning now to attend or send representatives to the Third Annual USAF Navigation Symposium to be held late in 1980.

Editor's Note: As a supplement to this article, see "The Score" on page 15.

This list represents symposium participants who have agreed to serve as initial contact points for their respective organizations. Your individual concerns and recommendations can be raised to these officers.

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Berlin Airlift: flying the corridors

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Numerous statistics confirm the success of the Berlin Airlift. For instance, from 26 June 1948 until 1 August 1949 when the phaseout of aerial resupply began, more than 266,000 flights delivered 2,223,000 tons of food, coal and other necessities to the 2,250,000 citizens of Berlin. On 16 April 1949, the delivery of almost 13,000 tons during a special Airlift effort, "Easter Parade," actually exceeded the 12,000 tons delivered daily by rail, barge, and trucks before the Soviets imposed the blockade. During the blockade, the food ration increased from 1,600 to 1,880 calories a day for every citizen! Despite these statistics and detailed accounts of the Airlift, scant information is available in popular literature about the navigation aids and procedures used to maintain the vital air corridors to Berlin.

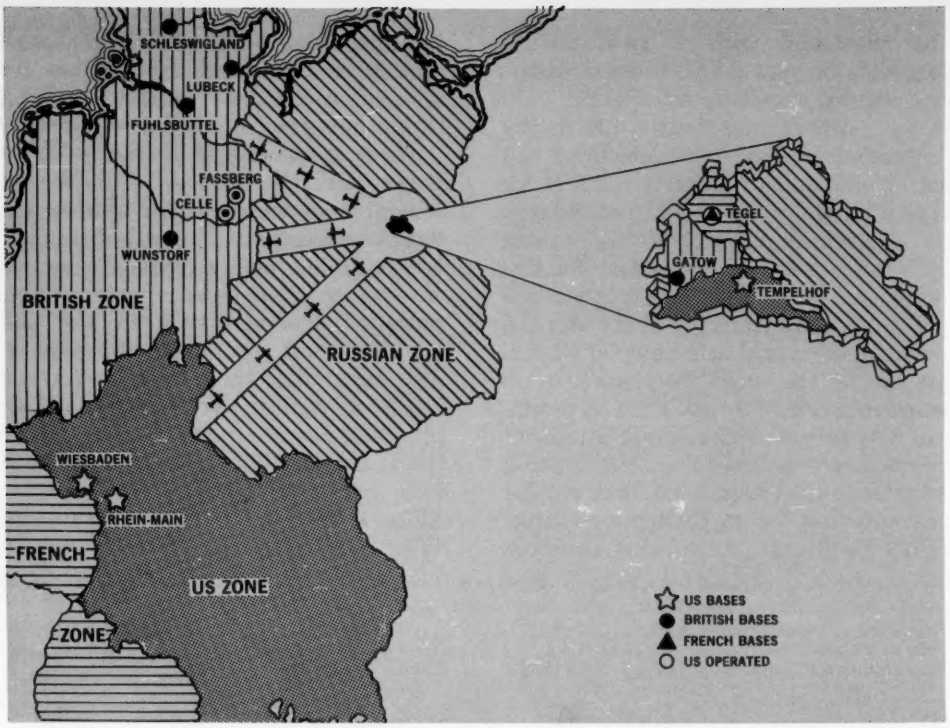

Figure 1. Corridors and bases.

This article describes these nav aids, the difficulties encountered in their use, and their employment on a typical flight from Rhein-Main Air Base in the American Zone of West Germany to Tempelhof Air Base in West Berlin. It first provides a brief background account of American aircraft and corridor operations.

The C-54 was the mainstay of the American effort, but other aircraft were also used in limited numbers for short periods. C-54s quickly replaced the C-47s used at the start of the Airlift since they could each haul 10 tons to the 3½ tons hauled by the C-47s. In addition, the Boeing C-97A and Douglas C-74 (C-124 forerunner) made approximately 81 flights from Rhein-Main to Berlin to test these new systems and to gauge the operations of large cargo aircraft carrying upwards of 20 tons. In addition, the Fairchild C-82 "Packet" carried bulky items and engineering equipment from mid-September until the end of the Airlift. These aircraft operated primarily in the American southern corridor and British central corridor.

A total of three 20 mile-wide corridors, established by treaty with the Soviets in November 1945, linked the British and American airfields in West Germany with the three Allied airfields in Berlin (Figure 1). The north and center corridors originated in the British Zone of West Germany and the south corridor in the American Zone. Aircraft generally traveled to Berlin along the north and south corridors and returned by the center corridor. And, since there was such a large volume of traffic in each corridor, horizontal and vertical separation of aircraft was necessary for safety and proper sequencing into Berlin.

A variety of altitudes and intervals between aircraft was tried. Most American aircraft used the south corridor into Berlin and flew at either 5,000 or 6,000 feet separated by three minutes between aircraft at different altitudes, six minutes between aircraft at the same altitude. Once airborne, the C-54s used a variety of aids to successfully navigate to a safe landing at Tempelhof Air Base, the principal American terminal in Berlin.

Several of these aids are familiar to today's airmen, but others are no longer in use. The aids included VHF radios, low frequency radio beacons (ADF), low frequency radio ranges, visual aural ranges, fan marker beacons, radar beacons, aircraft radar, and GCA and search radars. The Airlift served as a proving ground for some of the aids, demonstrated the need for improved aids such as VOR and DME, and influenced the structure of our present air traffic control system.

The VHF transceiver on the C-54 had only an eight channel/frequency capability, but each of the three bases in Berlin required four frequencies, one each for the search radar, GCA, ground, and tower controllers. Therefore, 12

discrete frequencies were used in the Berlin area since the three bases were so near one another. Each of the aircraft did not require all of the Berlin frequencies, but the possibility of diversion made it desirable to have at least 5 of the 12 frequencies. The crews also needed additional frequencies for the return to, and landing at, their home base. As a solution, ground station frequencies were duplicated as much as possible. There was also a plan to modify the C-54 eight-channel radio to a 16-frequency capability, but this change was not completed before termination of the Airlift.

The most numerous ground-based aids were low frequency radio beacons operating in conjunction with the aircraft's radio compass. Since European radio stations often used similar frequencies, interference sometimes adversely affected reception. In addition, once the original 50 watt transmitters were found unreliable for continuous operation, they were replaced with 500 watt beacons. However, these beacons were so powerful that they, in turn, often interfered with European radio stations! This problem was never resolved. Although low frequency beacons are still used today, another important aid employed during the Airlift, the low frequency radio range, has since disappeared from the scene.

A four-course radio range station transmitted radio signals along four narrow (3° wide) sectors called beams or legs. The pilot heard a steady monotone "on course" signal in his headset when the aircraft was located on one of the legs. If the aircraft moved off the leg, the signal gradually changed from a monotone to a series of dots and dashes (.—.—, "A" in Morse code) on one side of the leg or to a series of dashes and dots (—.—., "N" in Morse code) on the other side (Figure 2). The range stations operated continuously and broadcasted a three-letter identification every 30 seconds.

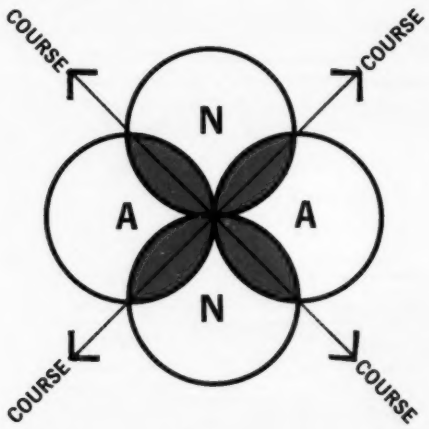

Figure 2. Radio range. Overlapping A-N signals form four distinct courses.

The three radio ranges used by the C-54s for homing and fixed-course navigation between the American Zone and Berlin had two serious disadvantages. Like the ADF stations, the frequency range often conflicted with European radio broadcasts, and the leg information was sometimes unreliable. Because of these deficiencies, visual aural ranges (VARs) were installed to provide navigation assistance in the corridors.

Similar to the radio range, the VAR transmitted an audible A-N signal, but only on two of the four legs. For the other two legs, a blue light inside the aircraft illuminated for deviations to one side of the leg and a yellow light illuminated for deviations to the other side.

One VAR was installed on the western side of each of the three corridors and one on the Berlin side of both the northern and southern corridors. A sixth VAR was located just inside the British Zone next to the center corridor, but it projected a leg perpendicular across the southern corridor to serve as a checkpoint for aircraft traveling the southern corridor. The final locations of these ranges did not always allow projection of the leg down the centerline of the corridor, but the signals were more reliable and less susceptible to interference than the signals of the radio ranges.

Since the VARs operated on VHF frequencies, the crew employed the VHF "localizer" receiver of the "glide path" indicator for VAR navigation. In addition, only one leg of the four available from each of the VARs could be used because of the orientation of the routes flown by Airlift aircraft. Although the VARs helped to overcome some of the deficiencies of the radio ranges, a fan marker beacon was designed to provide an additional capability for both the radio ranges and the ADF stations.

Since neither ADF nor radio range provided precise station passage information, plans were initiated in October 1948 to install fan marker beacons at each of the ADF and radio range stations. A fan marker transmitted a continuous low frequency vertical beam with a lens or bone-shaped cross section directly over the ADF or radio range station (Figure 3). The pilot automatically received positive position information by a flashing light or aural signal through his headset as he passed over the beam. Since fan marker beacons were not immediately available in Europe or the United States, only

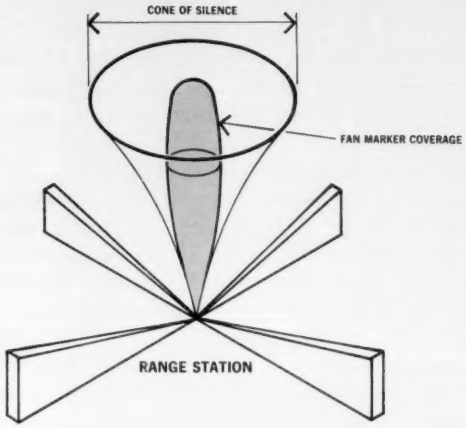

Figure 3. Fan marker beacon.

three were installed before termination of the Airlift. The ground-based radars used throughout the Airlift were much better aids than the fan marker beacons.

The two GCA units, operating continuously in VFR and IFR conditions at each Airlift airfield, and the CPS-5 search radar on top of the eight-story Tempelhof Airdrome building in Berlin, made the most effective contribution to the successful delivery of goods during the Airlift. Initially, GCA controllers could land only one aircraft every 15 minutes, but as their proficiency increased they reduced this interval to three minutes. Without this capability, it would have been impossible to sustain the high volume of air traffic from November through March when IFR conditions prevailed 70 to 80 percent of the time.

The CPS-5 search radar went into operation in January 1949 and controlled all aircraft from all three corridors until each was turned onto final approach at one of the three destination airfields in Berlin. Prior to installation of this radar, aircraft were either stacked in holding patterns or sent back to their home base if they were not evenly spaced. In addition, the high volume of traffic in the limited confines of the Berlin area constituted a safety hazard. The CPS-5 radar alleviated both of these problems and provided a reliable skin paint out to 60 miles.

The CPS-5 system, however, could not receive IFF signals. Aircraft had to be turned 45 degrees off course for 45 seconds to allow positive identification. This procedure might not have been necessary if the aircraft radar sets and ground-located radar beacons had been used more effectively.

Fifty-three percent of the C-54s were equipped with radar by January 1949, and all aircraft had radar sets by May. Radar beacons that provided identification, range, and bearing through a series of coded dashes on the aircraft radar scopes were installed at Rhein-Main in March and at Tempelhof in June (Figure 4). However, these aids were never fully exploited because of inadequately trained crews, improper maintenance, and insufficient radar beacon locations.

Figure 4. Radar beacon presentation. Bearing of the station is 030 degrees and range is measured to the innermost dash.

On a typical flight from Rhein-Main to Tempelhof, the aircrews employed available navigation aids in the following manner (Figure 5). After takeoff from Rhein-Main, the pilot maintained a predetermined ground path until he

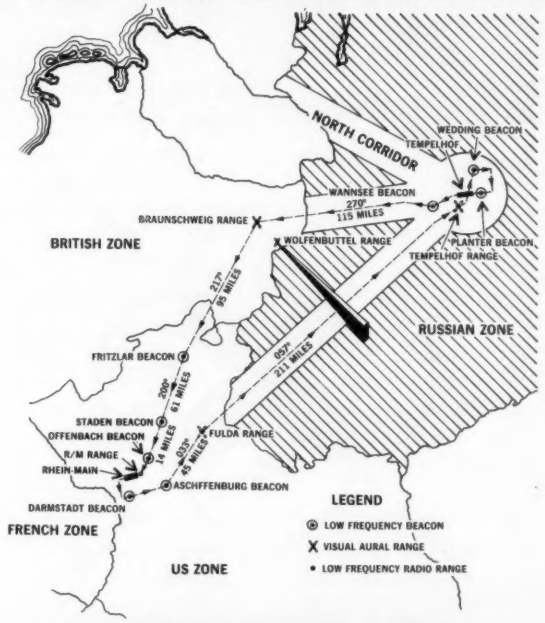

Figure 5. Round trip, Rhein-Main—Tempelhof.

reached 900 feet. At that point, he turned to Darmstadt ADF while climbing at 155 mph and 300 to 400 feet per minute. After reaching Darmstadt and his assigned altitude, he maintained a constant 170 mph and turned to Aschaffenburg ADF. After turning over Aschaffenburg ADF toward Fulda VAR, he listened for the preceding aircraft's time of arrival over Fulda VAR transmitted over VHF radio. He then adjusted his airspeed to arrive over Fulda range exactly three minutes after the aircraft preceding him. On reaching Fulda range, he transmitted his time to the trailing C-54 so that the pilot of that aircraft could achieve the required three-minute spacing.

After leaving Fulda range, the crew initially used the 3°-wide leg from the radio range to maintain position in the 211 mile-long corridor. Forty minutes after departing Fulda range and approximately 70 miles from the Tempelhof range, the pilot contacted Tempelhof control. A perpendicular beam to his course from the VAR in the British Zone near the center corridor provided a fix for a position report. The Tempelhof controller then used the CPS-5 radar to direct the aircraft from this position into Berlin. A leg was also available from the Tempelhof radio range for navigation during this portion of the flight.

The radar controller instructed the pilot to descend to 2,000 feet and decrease airspeed to 140 mph prior to reaching Tempelhof range. On arrival over the range, he was directed to the Wedding ADF. The C-54 further descended to 1,500 feet and turned to downwind after passing Wedding ADF. After a radar-directed turn onto final, the pilot was either handed over to a GCA controller or directed to make a visual approach, depending on weather conditions. While on final, he could use Planter ADF off the end of the Tempelhof runway as a final navigation check.

Early experience at stacking aircraft in holding patterns on arrival in Berlin showed that a greater volume of traffic could be handled if aircraft were descended enroute and allowed only one approach. Therefore, if the pilot missed his first approach, he had to return along the center corridor to his home base without offloading his cargo. The return to Rhein-Main was made in a similar manner by using radio beacons, ranges, and radar.

The Berlin Airlift not only demonstrated to the Soviets the futility of the land blockade, but also provided valuable information about the type of equipment and the procedures necessary for safe and accurate navigation. The limitations of ADF, radio range, and visual aural range placed a premium on the development of improved aids, such as VOR and DME. On the other hand, the successful use of GCA and approach radar greatly influenced the structure of our present air traffic control system.

A 1965 graduate of the Air Force Academy, Maj Specht served in Vietnam as an F-4C pilot and as a Forward Air Controller. In 1973, he obtained a master's degree in History from the University of Nebraska and subsequently served as Assistant Professor of History at the Air Force Academy. Maj Specht now is assigned to Travis AFB as a C-5 pilot with the 75 MAS.

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